Watershed Management Conference

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

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THE CHALLENGE OF WATERSHED MANAGEMENT IN ADMINISTRATION

By
P. D. Hanson

We all have a vital interest in the field of Watershed Management. All of the activities of the Forest Service in Region One may affect in some degree the volume, quality and timeliness of release of the water produced on the national forests. The Watershed Management meeting held this year is a step forward in meeting and discussing the varied problems which confront the land manager. We are charged with the responsibility of managing the national forest lands on a multiple-use basis and one of the most important products is an adequate flow of pure water. The papers presented at the meeting have been assembled and copies are available for all rangers and supervisors.

The information presented in these papers is stimulating and thought provoking. The discussions which followed were very enlightening. I want to take this opportunity to express my appreciation to all those who participated and made this meeting a successful one. I hope you find these papers as interesting to you as they have been to me.

As a result of the meeting, we expect to prepare some guidelines and manual instructions that will be helpful to you in solving your daily problems.

THE CHALLENGE OF WATERSHED MANAGEMENT IN RESEARCH

By
Reed W. Bailey

Director Bailey discussed the geologic norm in relation to watershed management. He pointed out that water is rapidly becoming not only physically and economically important but also politically important.

The landscape we have came to us from the past and we had nothing to do with its development. The streams had a certain regimen and silt load and this was the geologic normal. This development of the geologic normal was created by the complementary and simultaneous development of soil and plants in a balance. Evidence of this exists many places, an outstanding example being the steep natural slopes up to 180 percent--or much beyond the angle of repose--on the Salmon River where soil and vegetation have developed in balance and undisturbed by man.

The hydrologic pattern has helped establish such balanced geologic norms. Where such balances have not been disturbed and the infiltration capacity not damaged, from 95 to 99 percent of rain and snowmelt water percolates into the soil mantle and becomes seepage flow. Under these conditions surface runoff is slight and erosion very negligible. Maintenance of this plant-soil-water balance under the impact of work on the land is the watershed challenge we face.

WATERSHED MANAGEMENT IN RESEARCH

Status of present knowledge . . . . G. W. Craddock

Introduction

Watershed management research is a relatively new aid for the solution of problems in the control of water. Though new, sufficient research has been carried out to warrant the publication of two text books1/, each of which contains references to several hundred reports on specific investigations. Still other findings are being reported currently in Transactions of American Geophysical Union, Journal of Forestry, Journal of Range Management, Journal of Soil and Water Conservation, as well as in departmental and agency publications. The purpose of this statement is to summarize the highlights of what has been learned from watershed research to date, particularly with respect to findings that bear on R-1 and R-4 watershed problems.

1/ Kittredge, Joseph. Forest influences. McGraw-Hill Book Co., New York, N. Y. 1948.

Colman, E. A. Vegetation and watershed management. The Ronald Press Co., New York, N. Y. 1953.

Land Yields Water in Several Ways

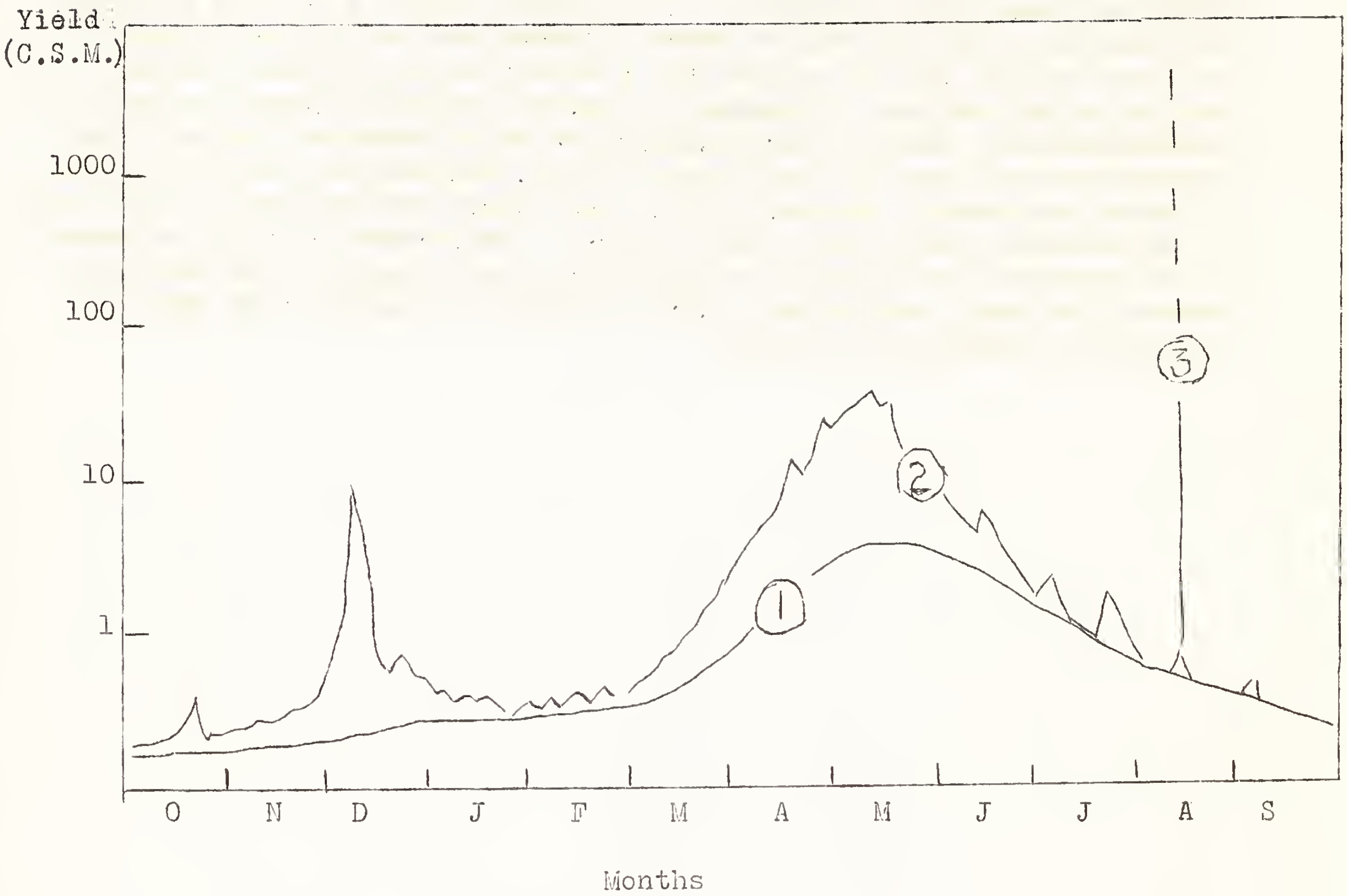


Fig. 1.--Typical mountain streamflow, Intermountain region.

1.--Base flow: Reaches channels by deep percolation. Is most desirable because it is filtered, relatively free of surges and prolonged.

2.--Seepage flow: Reaches channels by lateral seepage. Is also generally of good quality and delayed but may contribute to floods.

3.--Overland flow: Reaches channels by flowing over the land surface. Is generally unsatisfactory because of its short duration and is potentially dangerous because of its power to erode and to develop very high discharges.

Runoff is Strongly Affected by Climatic Factors

1. Annual water yields can fluctuate from more than 50 percent above average to less than 50 percent of average solely by reason of differences in precipitation.

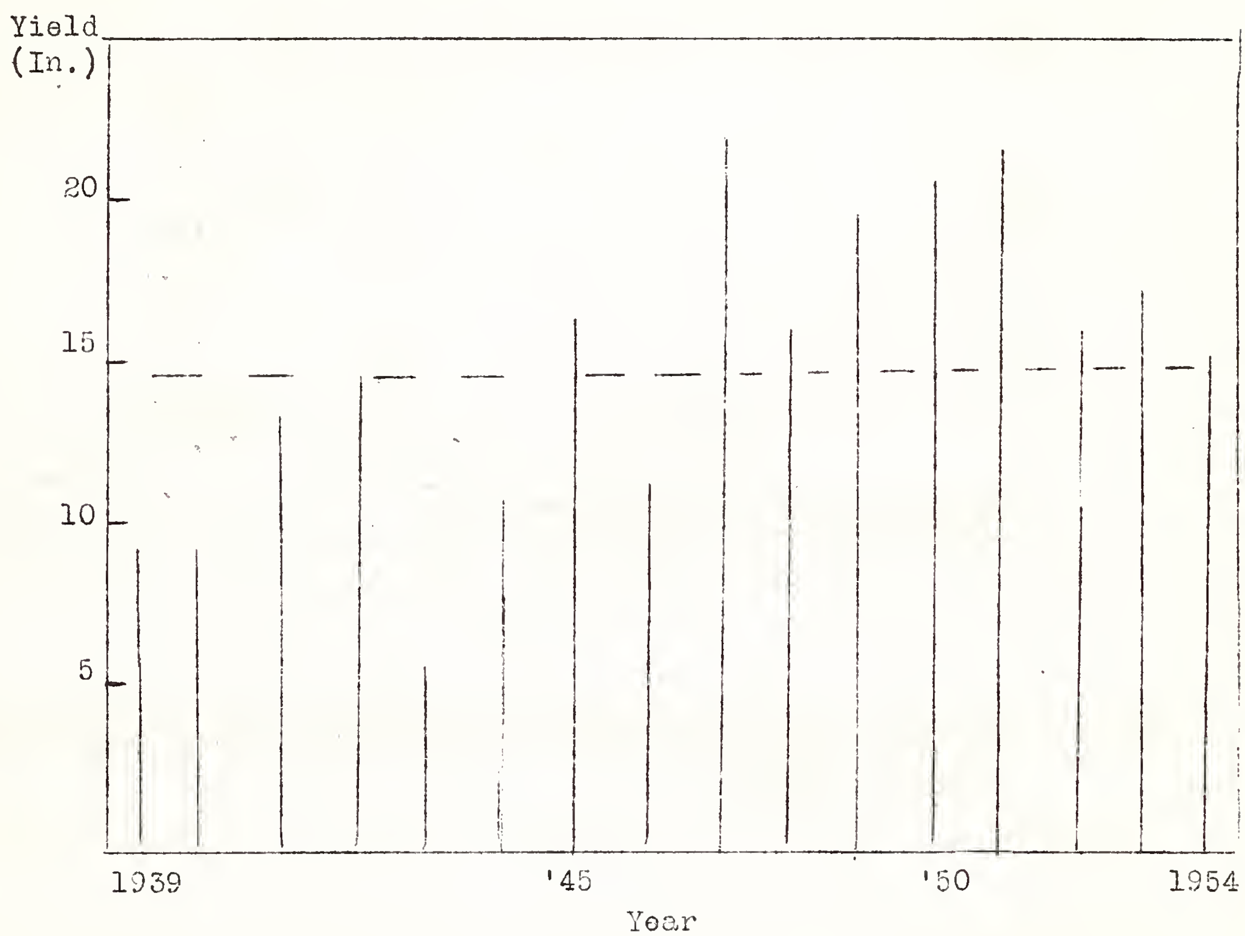


Fig. 2.--Annual runoff, Benton Creek, Priest River Experimental Forest, 1939-54.

2. Peak discharges can vary widely from year to year in both magnitude and time of occurrence by reason of differences in amount of precipitation and snowmelt temperatures.

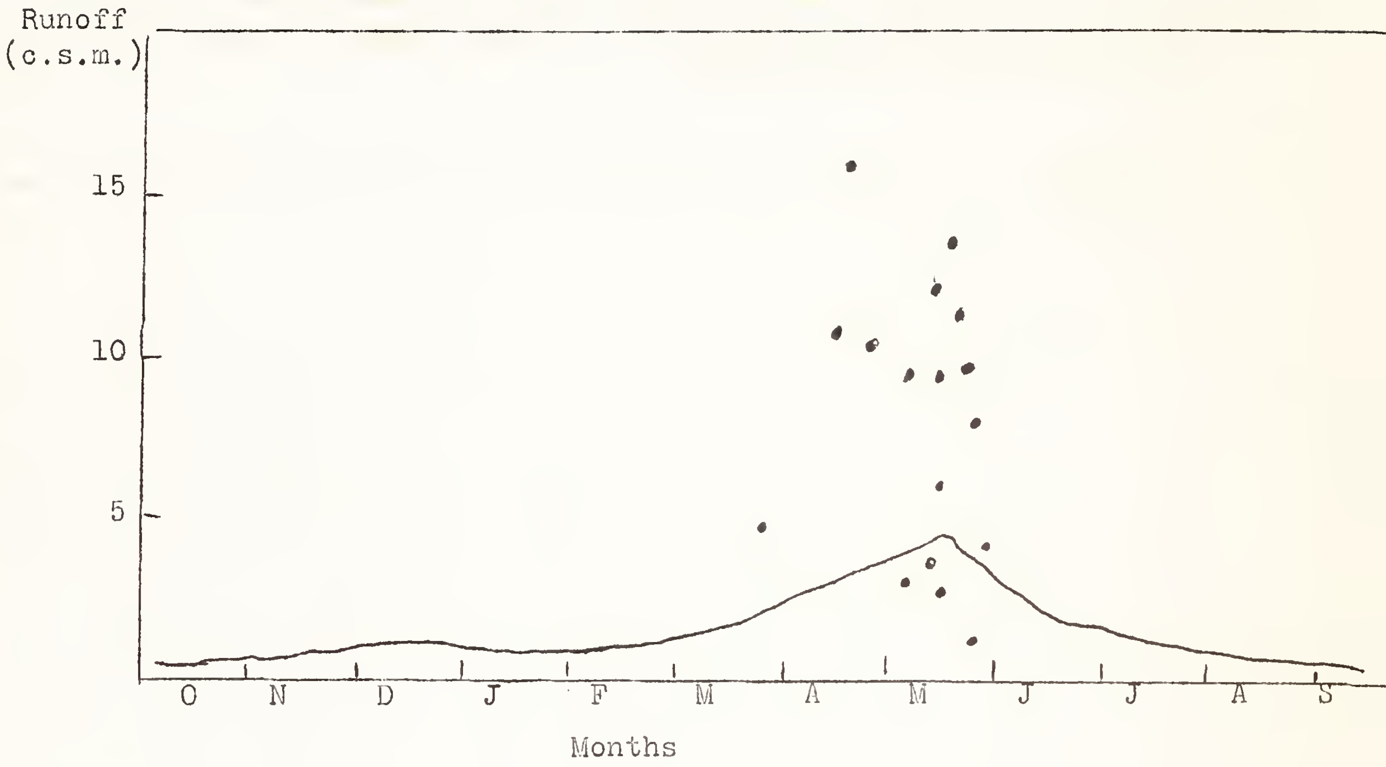


Fig. 3.--Average monthly discharges and variations in occurrence of maximum discharges, Benton Creek, Priest River Experimental Forest; 1939-55.

Runoff Also Affected by Land Form

Size, shape, steepness of slope, length of slope, depth of mantle, underlying rock formation and drainage pattern all affect runoff characteristics. Flood discharges tend to increase inversely with size of watershed. This emphasizes importance of careful management on small watersheds.

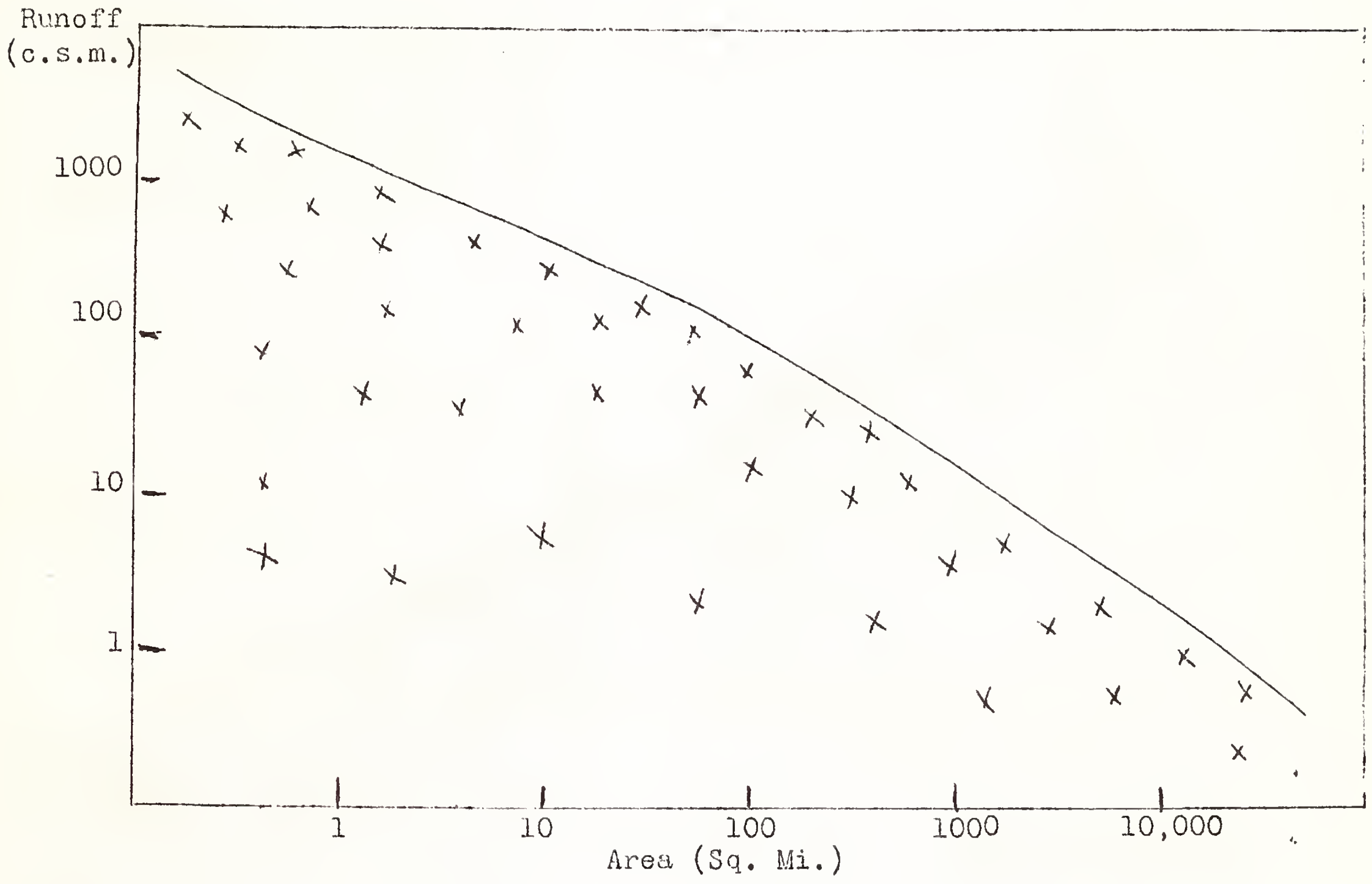
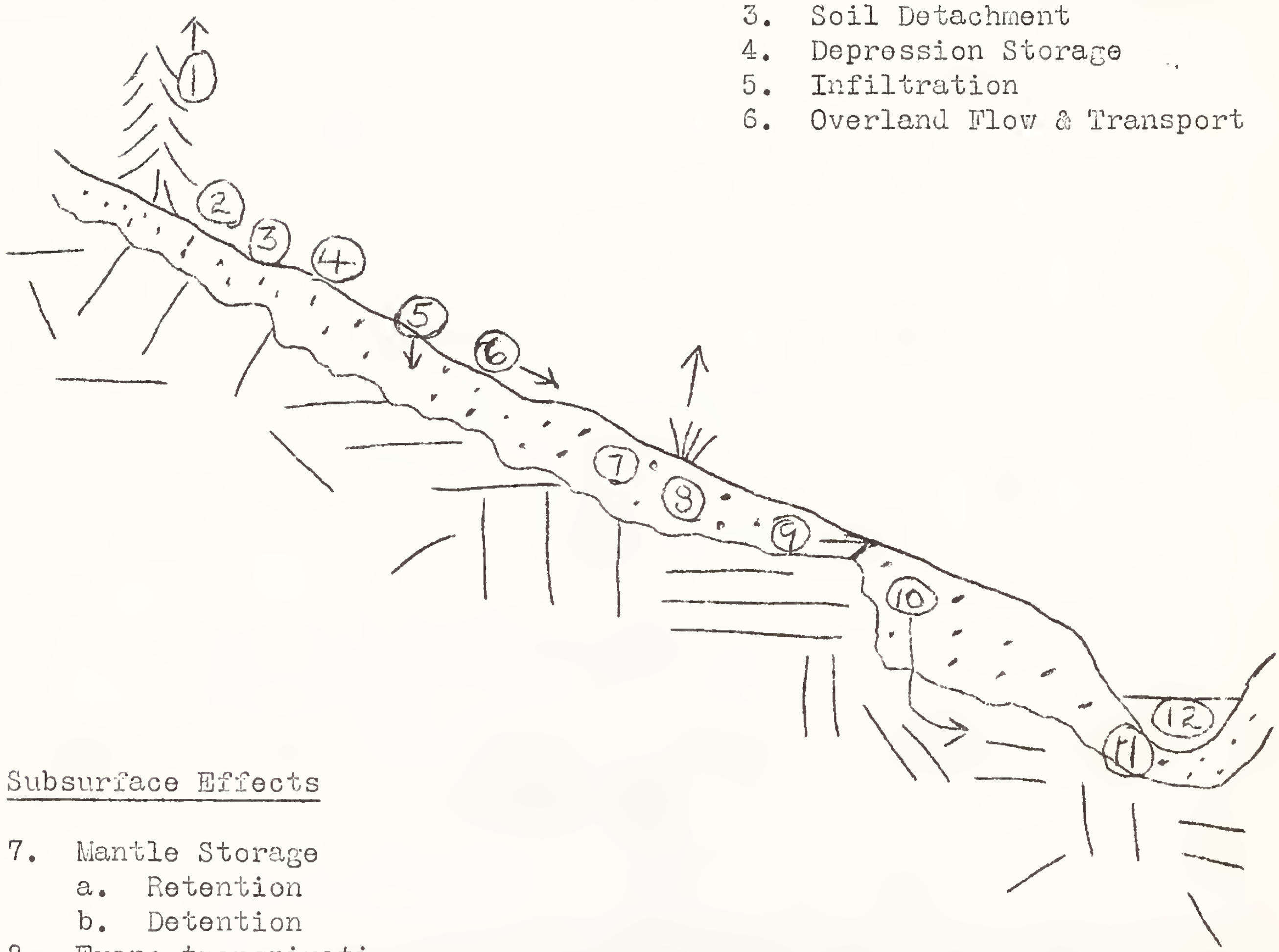


Fig. 4.--Relation of flood discharges to watershed area.

Plants and Soil Can Affect All Hydrologic Processes

Surface Effects

1. Interception & Evaporation
2. Snowmelt & Evaporation
3. Soil Detachment
4. Depression Storage
5. Infiltration
6. Overland Flow & Transport



Subsurface Effects

7. Mantle Storage
   a. Retention
   b. Detention
8. Evapo-transpiration
9. Lateral Seepage
10. Deep Percolation
11. Channel Storage
12. Streamflow

Fig. 5.--Processes in the hydrologic cycle.

Net Watershed Management Effects

1. Annual or seasonal water yields can be changed a little by altering evapo-transpiration losses.

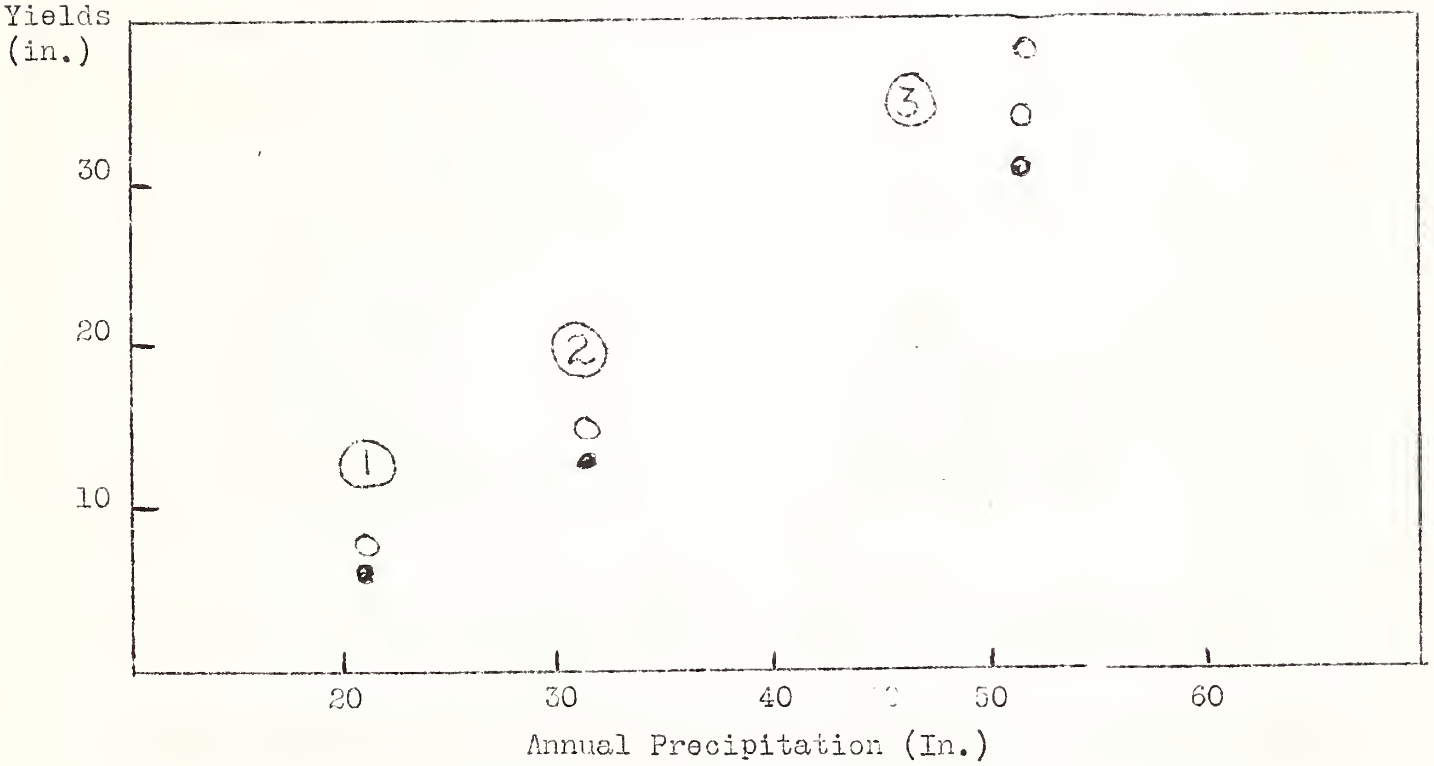


Fig. 6.--Watershed management effects on water yields in relation to precipitation:

1. Wagon Wheel Gap Experiment: Cutting and burning forest cover increased water yields about 25 percent for two years. Yields normal by 7th year after treatment.

2. Parrish Creek, Utah: Restoration of plant cover on flood source areas reduced yields about 10 percent in 18 years.

3. Clear cutting of aspen on plots, leaving herbaceous cover, increased water available for streamflow by 4 inches; baring the soil increased available water by 8 inches but created dangerous flood and erosion hazard.

2. Flood discharges can be changed substantially by altering interception, infiltration and mantle storage.

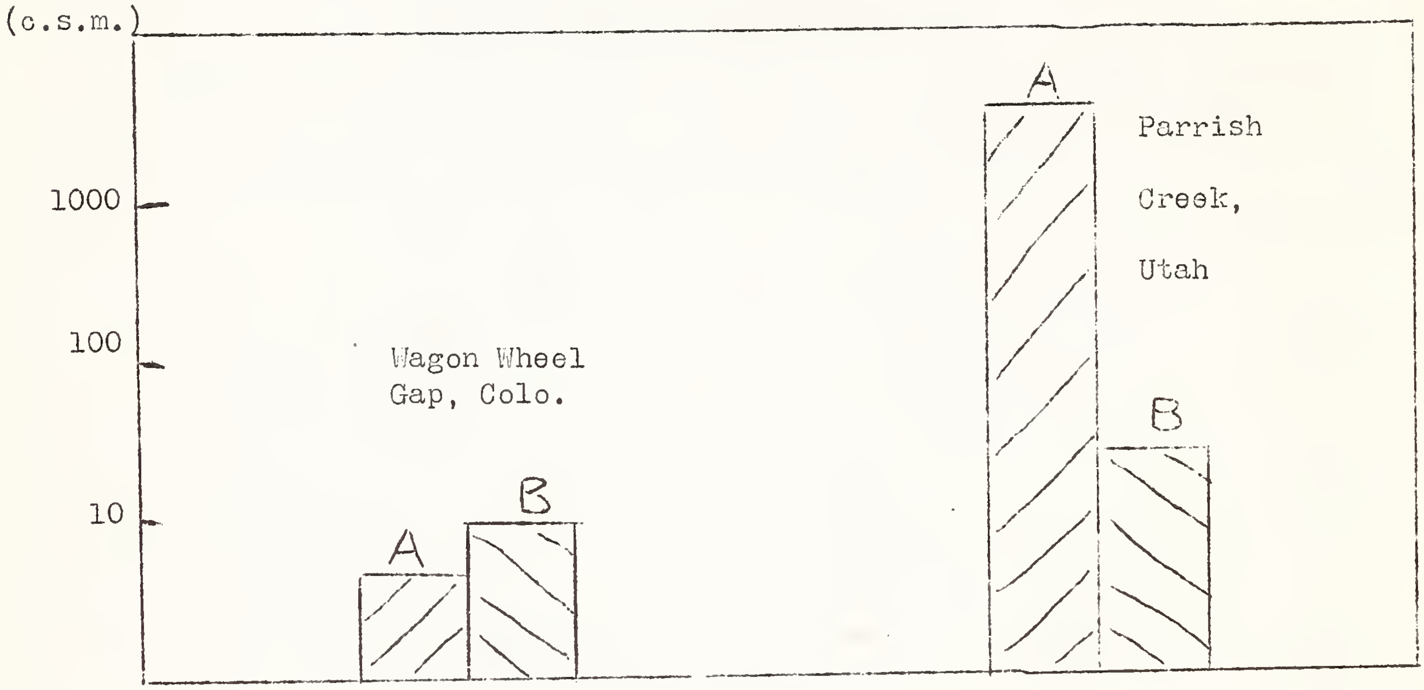


Fig. 7.--Flood discharges before (A) and after treatment (B) on two experimental watersheds:

1. Wagon Wheel Gap: Cutting and burning timber increased snowmelt discharges from 5 to 9 cubic feet per second per square mile of watershed during the first 2 years after treatment.

2. Parrish Creek: Restoration of plant cover on depleted flood source areas has prevented the recurrence of summer rain mud-rock floods having discharges on the order of 2,000 c.s.m. Maximum discharges now on the order of 20 c.s.m.

3. Sediment production can be altered drastically by altering the plant cover and surface runoff.

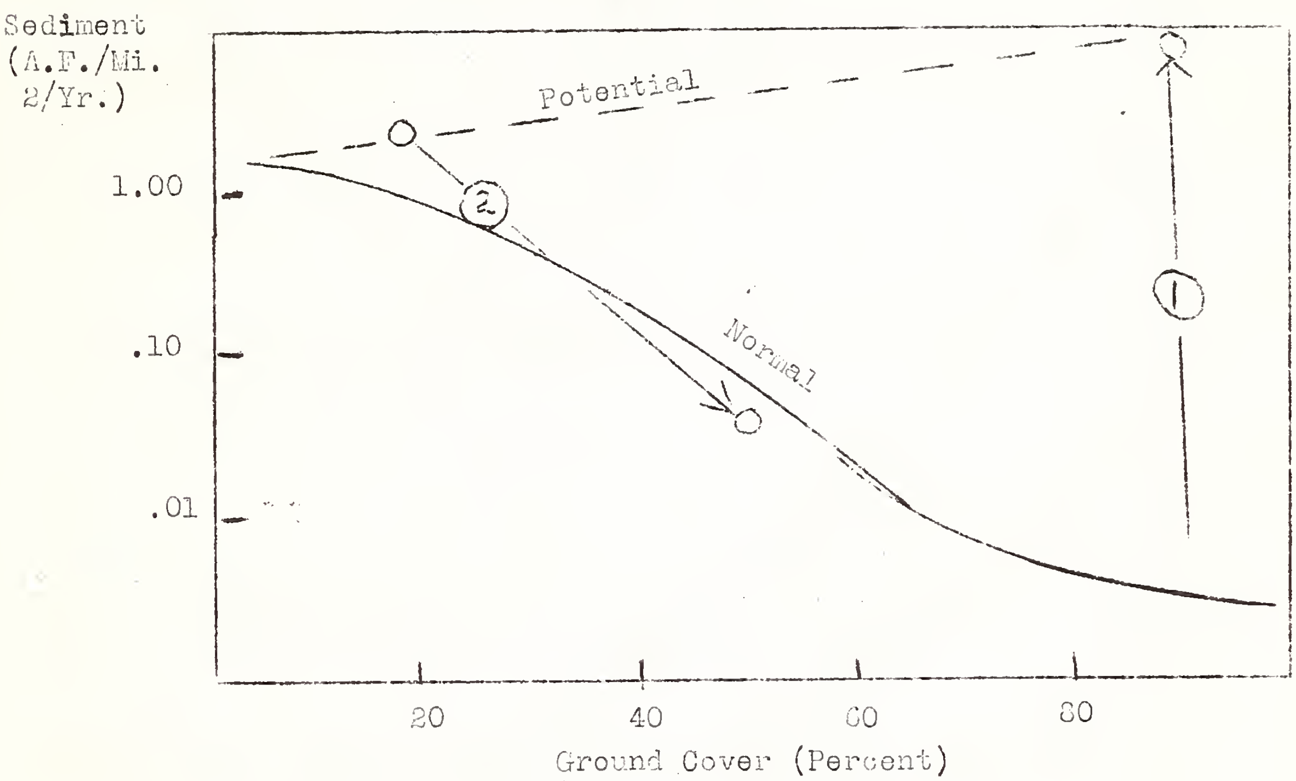


Fig. 8.--Normal and potential sediment production in relation to amount of ground cover. Naturally barren areas generally have high normal erosion rates but no potential for increased rates. Steep slopes having well developed soil and plant cover have low normal erosion rates but high potential for increased rates.

1. Depletion of plant cover on 10 percent of Parrish Watershed at Wasatch Resarch Center stepped up sediment production from less than .01 to 9.0 a.f./sq.mi./year. Restoration of plant cover has reduced sediment production to nearly normal in 18 years.

2. Increasing herbaceous cover from 16 to 50 percent on Area A at Great Basin Research Center, Utah, reduced sediment production from 2.0 to .06 A.F./sq.mi./year.

Adequate Plant Cover the Key to Storm Runoff Control

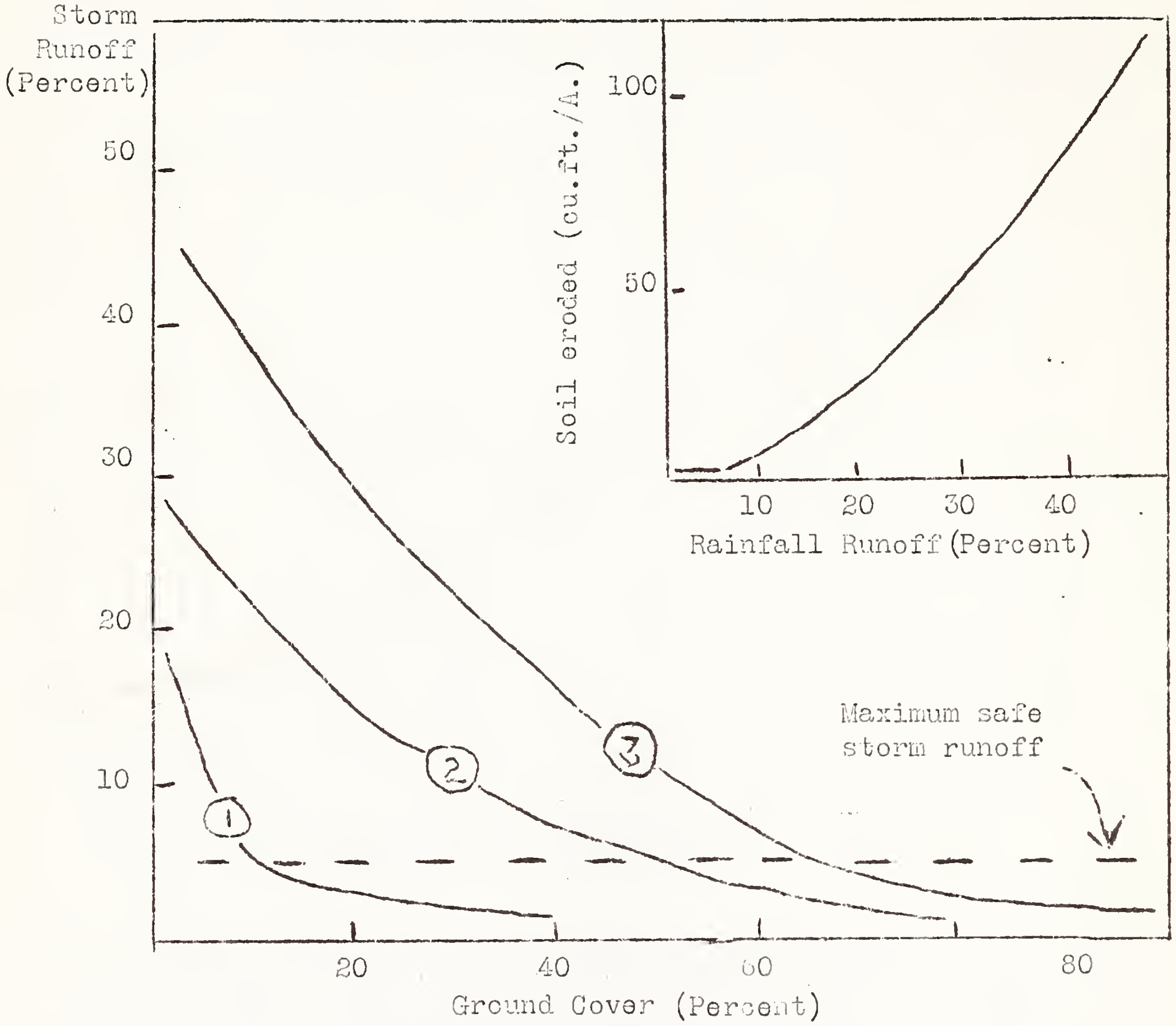


Fig. 9.--Ground cover requirements for controlling storm runoff and erosion under impact of summer rains, Wasatch R. C.:

1. Every year storm, less than 1.5"/Hr. max. rate.
2. Two-year storm, 1.5" to 3.00" per hour max. rate.
3. Five-year storm, 3.00" per hour or greater max. rate.

Note insert graph showing rapid increase in erosion when storm runoff exceeds 5 percent. Approximately 65 percent ground cover required for satisfactory control of erosion and storm runoff control during major storm.

WATERSHED MANAGEMENT IN RESEARCH

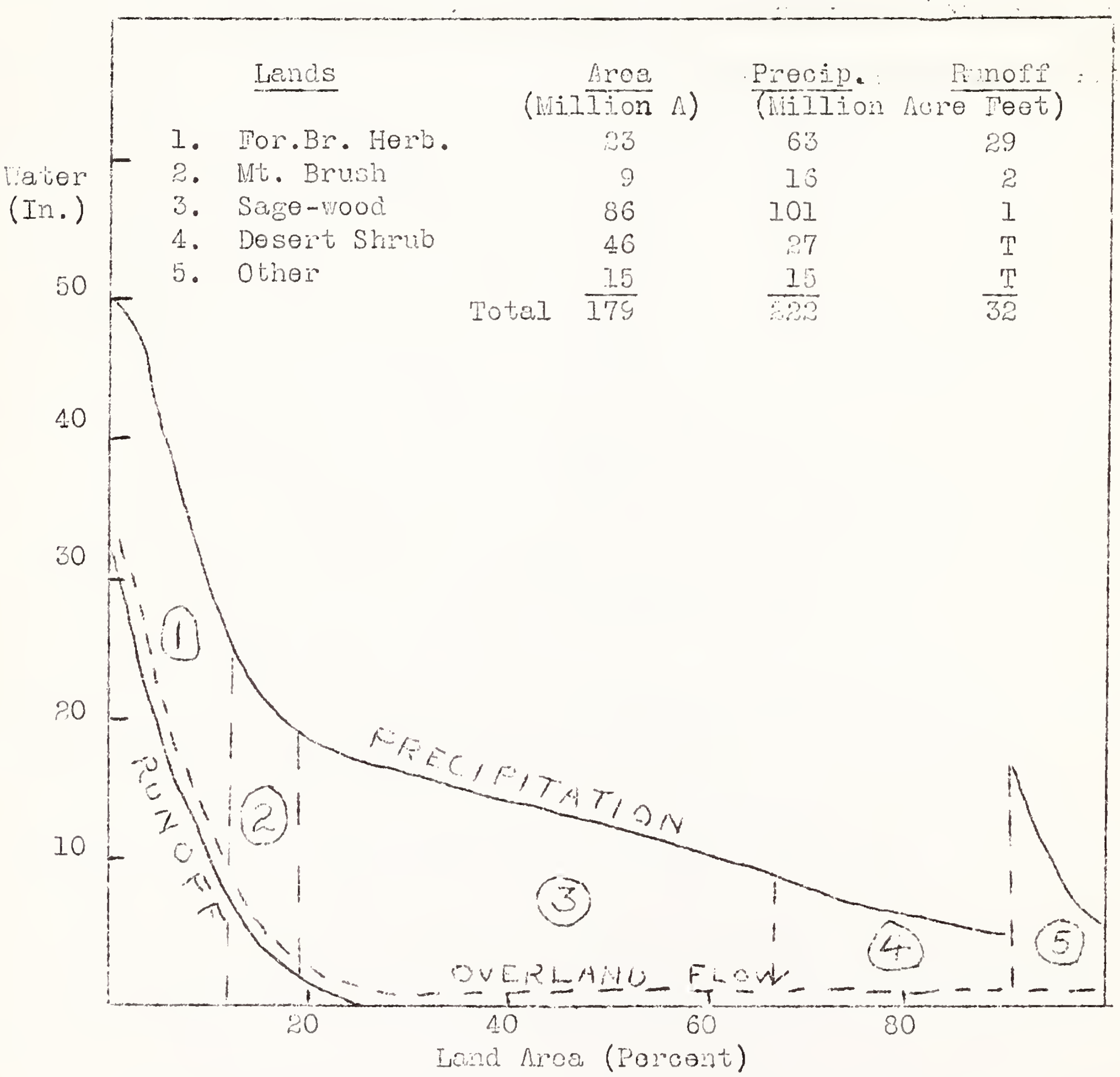
Present research program of Intermountain Station . . . .G. W. Craddock

Introduction

The Station's present watershed management research program includes a number of plot and watershed studies in the R-4 portion of the Station's territory, and an analysis of the watershed problems and research needs in the R-1 area. I propose to limit my discussion to the problems and going studies in R-4 as background for a more detailed consideration of the research needs in R-1 which will be presented by Packer.

R-4 Water Problems

The R-4 area is faced with critical problems of water supply, floods and sedimentation which have their source on the watershed lands. The supply problem is acute because only one-fifth of the lands receive enough precipitation to produce sustained streamflow. The flood and sedimentation problem is serious because all of the lands are subject to torrential rains that are capable of causing erosion and floods.



	Lands	Area (Million A)	Precip. (Million Acre Feet)	Runoff (Million Acre Feet)
1.	For.Br. Herb.	23	63	29
2.	Mt. Brush	9	16	2
3.	Sage-wood	86	101	1
4.	Desert Shrub	46	27	T
5.	Other	15	15	T
	Total	179	222	32

Fig. 1.--Average annual precipitation and runoff, R-4.

High Priority Watershed Research Problems in R-4

The R-4 forest and range lands present many problems of watershed restoration, maintenance and management. Some of these problems are of relatively low priority from a research standpoint because enough is known about them to proceed with action programs or because they involve little risk. There are many others on which research is urgently needed. The relative priority of the latter groups of problems is shown below, with notation as to which ones are currently under study.

R-4 Watershed Problem Areas	Types of Problems: Restore	Maintain	Manage
Subalpine Range	A-1*	A-1*	A-1*
Sp.-Fir-Lodgepole			A-4
Aspen-Herbaceous			A-2*
Ponderosa P.-D. Fir	A-4	A-2*	
Mountain Brush			A-3*
Grassland	A-2*	A-3*	A-5
Sagebrush			
Pinon-Juniper	A-3	A-4	
Salt-brush range	A-5	A-5	
So. Desert Shrub			
Stream Channels	A-6		A-6*

*Currently under study

Current Watershed Management Research Program

The present research program includes studies of problems on how to restore damaged watersheds, on requirements for maintaining satisfactory control of storm runoff and soil stability under grazing, timber harvesting and other uses, and on how to improve the amount and timeliness of water yields. These efforts are concentrated at the Great Basin, Wasatch and Boise Research Centers because lands are available at those places which are representative of some of the most serious watershed situations in the R-4 portion of the Station territory.

Great Basin R. C. - Studies at the G.B.R.C. are centered on the high elevation, clay soil-subalpine herbaceous range in the headwaters of Ephraim Creek. This type of range, with variations in soil and plant species, occurs extensively. It is choice summer range but because of abusive use is now seriously depleted and has become the source of destructive summer floods and damaging sediment. These areas are also a major source of streamflow from snowmelt. They thus pose problems of restoring and maintaining control of runoff and soil stability, and of increasing or delaying snowmelt yields. Studies are under way on all three of these problems.

Watershed Restoration Studies:

1. A long-term, paired 10-acre watershed study in which one area (A) is being used to determine the effects of natural revegetation on control of summer rain runoff and annual sediment production; the other area (B) for determining the effects of artificial reseeding.

2. A short-term infiltrometer and fixed plot study to evaluate the effects of restoration measures (protection from grazing, reseeding and contour trenching) on the infiltration, surface runoff, erosion and forage productivity characteristics of subalpine herbaceous, mountain brush, and juniper-sagebrush flood source areas in the Pleasant Creek watershed. This study is being made in cooperation with the SCS and NFA as part of the "Pilot Watershed" program.

Watershed Maintenance Studies:

1. Long-term infiltrometer plot study of the effects of seeding and subsequent grazing on the hydrologic and productivity characteristics of depleted subalpine range in Manti Canyon. This is a cooperative study with NFA to determine the safe limits of grazing use.

2. Similar but short-term plot studies are proposed for determining the effects of different intensities of grazing on the hydrologic characteristics of reseeded sagebrush range at Benmore, and of winter range at the Desert Branch.

Watershed Management Studies:

1. Long-term, paired 300 acre watershed study to determine the effects of induced snow drifting and cover management on the amount and timliness of water yields. This study requires further watershed calibration.

2. A short-term plot study of the effects of subalpine range species on soil mantle moisture storage deficits and forage production.

Wasatch R. C. - Studies at this Center have been concentrated on the Davis County Experimental Watershed. This study area embraces several very steep watersheds having a mixed forest, brush and grass cover. They are representative of many similar areas in R-4 where plant cover depletion, especially on the herbaceous and shrub covered portions, has brought on devastating mud-rock floods and drastically increased sedimentation. These lands are also the main source of vitally important water supplies. Though the restoration and maintenance of control of summer storm runoff and erosion is of most immediate concern there is also urgent need of finding ways to increase useful water yields. All of these phases are currently under study.

Watershed Restoration Studies:

1. A long-term, multiple watershed study of flood source restoration measures has been under way since 1936. Some watersheds have been intensively treated by reseeding and contour trenching, some less intensively treated, and some not treated. The effectiveness of the intensive treatments in preventing the recurrence of summer rain floods to date has been most encouraging. The study is also furnishing important information on perennial streamflow behavior.

Watershed Maintenance Studies:

1. A long term multiple plot study is furnishing guides on the amount of plant and litter cover that is necessary for maintaining control of summer storm runoff and soil stability on herbaceous, brush and aspen covered sites.

2. It is hoped that a study of livestock grazing effects on restored flood source areas can be initiated soon.

Watershed Management Studies:

1. A plot study is now under way to determine the effects of seasonal harvesting of reseeded summer range grasses on interception, surface runoff, erosion, mantle moisture storage, evapo-transpiration and net amounts of water available for seepage runoff. This is expected to provide useful guides for minimizing consumptive water losses.

2. A multiple watershed study of the effects of replacing low value brush and trees with herbaceous species on water yields is proposed for early reactivation.

3. An informal study in cooperation with local water users has demonstrated the feasibility of spreading and sinking surplus spring runoff into impounding trenches and in dense brush patches on low elevation bench lands.

Boise R. C. - Studies have been centered on ponderosa pine and foothill grassland range having very loose granitic soil and steep slopes. Accelerated erosion on depleted foothill ranges has long been recognized as a serious threat to the useful storage life of costly and essential multiple purpose reservoirs. Accelerated erosion during snowmelt as well as torrential summer rains has become increasingly serious with the recent and continuing extension of timber harvest cuttings into steeper and more remote areas. There continues to be a need for study on the range restoration and maintenance problems. However, in view of the growing seriousness of the erosion control problem in the ponderosa pine type, most of the current effort is being made on that problem. Two studies are now under way as follows:

1. A long-term evaluation study of the effects of different cutting and logging systems on erosion sources and sediment production. This study is being conducted as part of a long-term forest management study in the Boise Basin Experimental Forest and embraces 16 treated and 4 untreated subwatersheds.

2. A short-term plot study of logging road and skidtrail erosion control methods. This study is being carried out on 4 timber sale areas in cooperation with NFA and timber operators.

WATERSHED MANAGEMENT IN RESEARCH

Watershed management problems and research needs in the Region 1 area

Overall situation . . . . P.E. Packer

A. Introduction

1. Watershed Management

The objective of watershed management is the production of water, usually as streamflow, in the amount and quality desired at a time when it is needed. We try to accomplish this in the following ways: (1) By maintaining the conditions on watersheds that presently provide satisfactory control of water flow and erosion, (2) by repairing and restoring damaged watersheds to conditions that exert satisfactory control, and (3) by improving the water-yielding characteristics and erosion conditions of watersheds by treatment of land and vegetation. Here, then, we will consider watershed management to mean the management of timber, forage, and other resources in a drainage basin for one or more of the following effects:

1. Control of water quality
2. Reduction of flood discharges
3. Maximum amount of water yield
4. Timing of water yield to meet water needs

Sediment decreases water quality. It also aggravates flood discharges. Loss of soil reduces the capacity of land to absorb and store water and hence. to regulate the amount and timing of water yield. Prerequisite. then, to each of these objectives is a stable soil mantle.

There is a tendency on the part of some of us to confuse these specific objectives in watershed management with the over-all land management or multiple use objective--that of achieving maximum use of all of the resources in a drainage basin. As defined here, the goals of watershed management are usually compatible with those of forest management, range management, and other resource uses by virtue of the fact that all require stable soil. Beyond this, however, there can be real divergence in watershed management and multiple use management goals. This divergence lies in the fact that the conditions needed to produce desired streamflow are not necessarily those that are required for producing maximum yields of timber, or forage, or wildlife. For example, the need for high-quality water and reduction of flood peaks as desired watershed management goals may require curtailment, or even elimination on some areas, of timber cutting. On the other hand, where greater yield of water is a watershed management goal, the amount of growing stock needed for maximum timber yield may need to be reduced;

or species inferior for timber, but which do not use as much water, may be required. Such decisions can be determined only by weighing the relative importance of specific needs in specific localities.

2. Watershed Management Research

The job of watershed management research is to furnish understanding of the processes that control the quality, amount, and timing of runoff; and to prescribe the land management practices needed to make use of these processes for every intent of watershed management. This means to learn how to maintain, restore, and improve the watershed conditions needed for production of desired runoff under many different circumstances. The variable effects of topography, geology, and climate on the quality and amount of water yield is one kind of circumstance. The requirements for and methods of harvesting timber and forage create still different circumstances affecting water quality and rate of delivery. Other kinds of land treatment such as road building and mining and use of fire, are capable of exerting pronounced and highly variable effects on water. Research needs to learn where we can do something and what we can do to ameliorate the water problems that arise from man's use of these resources. But research also needs to learn what to do and how much can be done to manage land for water alone, irrespective of timber, forage, or other resource uses.

B. The Water Situation in the Columbia-Missouri Basins

The Northern Region straddles the Continental Divide from which two great river systems--the Columbia and Missouri--originate. In its far-reaching effects throughout these immense drainages water is the most important natural resource. For a few minutes let us consider just how important water is to the economy and development of these two drainage basins.

1. Amount of Water

a. Columbia River Basin:

The Columbia River Basin covers an area of about 166 million acres which discharge a total average annual runoff of about 180 million acre feet. That portion of the drainage within Region 1 amounts to about one-fifth of the land or nearly 35 million acres from which about 41 million acre feet or nearly one-fourth of the runoff is derived.

b. Missouri River Basin:

The Missouri River Basin covers an area of 339 million acres or just about twice the area of the Columbia. Average annual runoff at the mouth is about 59 million acre feet. The Region 1 portion, covering about 82.2 million acres, or 24 percent of the Basin, furnishes about 17 million acre feet, or 29 percent of the runoff.

2. Water Developments and Costs:

a. Columbia River Basin:

The Columbia River is endowed with great potentialities. Second only to the Mississippi in volume of flow and with a much steeper gradient, it can produce power in abundance. Much land needs only the development of irrigation distribution systems to become productive for farming.

Presently there are about 4 million acres under irrigation. Comprehensive plans include irrigation of 3.8 million additional acres and supplemental water for 1.5 million acres now irrigated.

Installed hydroelectric power capacity is about 2.9 million kilowatts or 15 percent of the nation's developed capacity. Potentially, the Columbia River is one of the greatest power-producing streams in the world. Existing plans, if carried out, would create approximately 13.1 million kilowatts installed capacity. The potential capacity is estimated at nearly 34 million kilowatts or 40 percent of the nation's total estimated potential.

The total invested value of irrigation, power, and flood control developments in the Columbia Basin today is approximately 2 billion dollars. Installation of authorized and recommended developments would bring this investment to about 7.6 billion dollars, of which 1.9 billion alone would be in dams.

b. Missouri River Basin:

The potential for the Missouri River lies in its development for irrigation agriculture more than anything else. Currently, there are about 5 million acres under irrigation. Proposed plans include about 2.5 million more acres plus supplemental water to a quarter of a million acres now irrigated. Irrigable land in the Missouri, if fully developed, is estimated at nearly 13 million acres.

Installed power capacity is only about .6 million kilowatts. Authorized and approved developments would increase this to 2.2 million kilowatts. The potential for development--nearly 7.5 million kilowatts--is still only about one-fifth of the Columbia's potential.

Live storage capacity of existing reservoirs on the Missouri is over 16 million acre feet. This storage plus that under construction will provide nearly 49 million acre feet.

Invested value of the irrigation, power, and flood control facilities in the Missouri River Basin today is about 1.9 billion dollars. Completion of projects under construction plus those authorized and recommended would raise this investment to nearly 8.5 billion dollars of which 1.8 billion would be in dams.

Thus, the total value of water handling facilities in the Columbia and Missouri Basins that are dependent in large measure upon clean, useable water from the forest and range lands of Region 1 is about 3.9 billion dollars. Developments which could eventually increase this value to over 14 billion dollars have already been proposed.

3. Water Problems

Of primary and recurring concern to the people of the Columbia and Missouri River Basins have been the problems of:

1. Snowmelt flood damage, especially along the main stems.
2. Sediment deposition in stream channels, reservoirs, municipal water supplies, irrigation facilities, farm lands, and urban developments, especially in the Missouri.
3. Shortages of late summer water supplies for irrigation.
4. Shortages of winter water supplies for power generation, especially in the Columbia.
5. Local flash flood damage from high-intensity summer rainstorms, more prevalent in the Missouri.

Snowmelt floods, often aggravated by heavy rains, have occurred periodically on the Columbia, more frequently on the Missouri. Average annual flood damage on the Columbia has been in the neighborhood of 35 million dollars. On the Missouri it has averaged nearly 60 million dollars. Although a wide variety of conditions can cause major floods in both drainages, rapid snowmelt following cold spring weather, and in combination with heavy rainfall, is the major cause.

The Columbia River carries a sediment load estimated at about 19 million tons annually. This is somewhat less than the 200 million tons estimated for the Missouri, but still enough to create substantial damage to downstream water-handling structures. About three-fourths of the sediment movement in these streams occurs during snowmelt runoff periods.

Some sections of both Basins have suffered periodic and substantial crop damage because of insufficient water for irrigation in late summer. This situation has been most prevalent in the Missouri Basin. Low winter flows have resulted in "brown-outs" or inadequate power generation, especially with increasing industrial demands in the Columbia Basin.

The major problems of floods and water shortages occur because the supply is poorly distributed. Sometimes there's too much; sometimes too little. Both problems can be alleviated to great extent. If all the streamflow were somehow distributed uniformly throughout the year, floods, irrigation deficiencies, and power shortages would not exist. The obvious answer is large storage

dams to regulate streamflow. Those projects proposed for the Columbia and Missouri Rivers should pretty well provide the solution for these problems insofar as downstream interests are concerned.

Despite this, there are two problems that storage and streamflow regulation through big dams will not handle. One of these is continuing sedimentation with its attendant depletion of storage and its high maintenance costs. The other is the fact that large dams will not prevent flood discharges nor water shortages above them in the upper watersheds where sizeable investments exist in both rural and urban developments. To prevent or reduce flood damage in these upstream sections, and to protect the life of downstream structures and the billions of dollars in industrial and agricultural reliance placed upon them, every effort is needed to regulate the quality, quantity, and timing of streamflow from upstream watershed lands. More specifically, this means to: (1) reduce erosion, (2) depress snowmelt flood peaks, (3) prevent local "flash" floods, and (4) increase the amount of late summer streamflow. Depending upon specific needs in specific places, these are the major watershed management objectives in Region 1.

C. General Characteristics of Region 1 Watershed Lands

From a hydrologic standpoint the precipitation, runoff, soil, and vegetative characteristics on the Columbia and Missouri sides of the Region are vastly different. There are many facts and aspects about these characteristics of which little is known. Review of the things we do know, however, will assist us in more closely pinpointing watershed management problems and the areas where they are important.

1. <u>Precipitation</u>

About 70 percent of the land area in the Columbia River portion of Region 1 receives more than 20 inches of precipitation annually. Forty percent receives more than 30 inches and 4 percent receives more than 60 inches.

On the Columbia side of the Continental Divide there are two different types of precipitation climate separated by the Bitterroot-Coeur d'Alene-Selkirk mountain crest. Westerly winds drop much of their moisture in crossing this barrier, resulting in greater precipitation at comparable elevations on the west side than on the east. Heaviest rainfall in the section east of these mountains comes during April, May, and June. These, also, are generally the months of heaviest snowmelt runoff. Summer rainstorms of moderately high intensity occur but generally not as frequently as on the Missouri side.

By comparison, about 70 percent of the land in the Missouri portion of the Region receives less than 15 inches of precipitation annually. Only about 1 percent receives more than 20 inches.

The most significant climatic feature of the Missouri portion of the Region is the great degree of variation in precipitation from year to year, especially in the plains section of eastern Montana. Here, well over half of the annual precipitation of 10 to 15 inches comes as rain during the early summer and most of the remainder as winter snow. Summer precipitation is mostly of the thunderstorm type with high rainfall intensities. Much of this precipitation is lost by rapid runoff which carries with it considerable sediment. In the higher mountains and valleys of the western part of the Basin, most of the annual precipitation of 15 inches or more occurs as winter snow.

2. Runoff

The average annual runoff from nearly 35 million acres in the Columbia River portion of the Region is about 14 inches. This represents about 41 million acre feet of streamflow. Of this amount about 27 million acre feet or 66 percent originate on 17.8 million acres within exterior National Forest boundaries. The main streams, as well as tributaries, have steep gradients. Tributaries are numerous, but generally short, and drain rather small areas individually. Greatest runoff occurs from snowmelt in April, May, and June.

In the Missouri River portion of the Region a little more than 82 million acres yield an average of about 2.5 inches of runoff. This amounts to about 17 million acre feet of streamflow. Of this, about 6.2 million acre feet or 36 percent originate on 10.1 million acres within exterior National Forest boundaries. With the exception of small headwater tributaries with steep gradients, the Missouri River flow is quite different from that of the Columbia. Many tributaries are large and long and their flow, like that of the main Missouri, is slow and sluggish. Snowmelt on the eastern Montana plains generally causes some rise in streamflow in April. A much greater rise is characteristic in June when snowmelt occurs on the higher plateaus and mountains in the western part of the drainage.

Depending upon the manner in which they produce runoff, we might say there are three kinds of watershed lands in Region 1.

1. The arid lands, which ordinarily contribute little but surface runoff to streamflow. Generally these lands produce less than 1 inch of runoff annually. About 46 percent of the Region or 54 million acres of land are arid. Ninety-eight percent of the arid lands lie on the Missouri side, stretching across eastern Montana.

2. The sub-humid or semi-arid lands produce some runoff as seepage flow, usually from snowmelt in the spring, but contribute only surface runoff during the remainder of the year. In general, these lands produce less than about 10 inches and more than 1 inch of runoff annually. About 36 percent of the Region or 42 million acres are sub-humid. Sixty percent of these lands lie on the Missouri side, mainly in southwestern Montana. On the Columbia side most of the sub-humid lands are on the western fringe of the Region, in the upper Clarks Fork drainage, and between the Flathead River and Selkirk Range.

3. The humid lands contribute nearly all of their runoff as seepage flow throughout the year. Generally these lands produce upward of about 10 inches of runoff annually. About 18 percent of the Region or 21 million acres are humid. Eighty-two percent of these lands are on the Columbia side, mainly in Idaho and against the Continental Divide, in Montana. On the Missouri side they comprise the higher mountain elevations, principally along the Continental Divide and in southwestern Montana.

With sufficient protective plant cover only a small part of the annual precipitation on all of these lands produces surface runoff. Most of it is disposed of either as seepage flow or to reduce soil moisture deficits. When the protective cover is damaged and the soil is laid bare, however, each of these lands is capable of producing substantial surface runoff.

3. Soil

There are many kinds of soil in Region 1 about which very little is specifically known. From a hydrologic standpoint we need more quantitative knowledge about such soil characteristics as infiltration, storage, detachability, and transportability, and about how these characteristics are altered by use. On the basis of their origin and observed reaction under the impact of use, however, the more extensive and important kinds of soil in the Region exhibit some hydrologically pertinent characteristics.

a. The granitic soils, because of their single-grain structure, are non-cohesive and gully badly when once cut by running water. These soils occur most extensively in humid and sub-humid areas, chiefly on the Bitterroot mountain mass as the Idaho batholith and as the Boulder batholith in western Montana.

b. The glacial silts, like the granite soils, tend to be single-grain in structure and are highly erosive once they have been cut by running water. These soils occur in humid, sub-humid, and arid areas, chiefly across the northern part of the Region.

c. <u>The loessal soils</u> are fine-textured and, where deep, have high storage capacity. These soils are erosive when exposed to running water. They occur most extensively in the humid and sub-humid areas in the western part of the Region.

d. <u>The andesitic and rhyolitic soils</u> are somewhat less permeable than the granitic soils but have more coherence and appear less subject to erosion. They occur predominantly in sub-humid areas throughout the mountains of western Montana.

e. <u>The basaltic soils</u> are generally fine-textured, have good storage capacity, and are moderately susceptible to erosion. They occur mostly in the sub-humid areas northwest of Yellowstone Park and near the western edge of the Region.

f. <u>The hard sediment soils</u> from shales and sandstones are silty, sandy, or gravelly loams, moderately permeable and deep, and highly subject to erosion. Several kinds of these soils are found predominantly in the arid plains region of eastern Montana where they have been cut deeply by stream channels. Other phases occur in the sub-humid area along the eastern side of the Lewis and Clark Range on pronounced scarp faces with steep dip slopes. Here the soil is rather shallow but still erosive. The dip and scarp nature of parent rock provides intake areas for seepage flow to underground artesian basins.

g. <u>The soft sediments and terrace soils</u> are poorly consolidated and deep alluvium. They are generally located on benchlands and foothills in arid and subhumid areas. Two factors make them serious contributors of surface runoff and erosion. One is the sparse cover that often characterizes them. The other is the presence of clay layers with low permeability which restrict percolation of water.

h. <u>The dolomitic soils</u> represent perhaps the most critical soils in the Region from the erosion standpoint. Fine texture and tight subsoil combine to make management of these soils difficult. They erode seriously even where the plant cover is only moderately disturbed. This is particularly true of the red clays. These soils cover extensive areas of the humid and sub-humid lands on the Beaverhead, Gallatin, Deerlodge, Helena, and Lewis and Clark forests.

4. Vegetation

a. Forest:

There are about 37 million acres of land in the Region classed as forest by the Forest Survey. Of this, commercial forest in all ownerships amounts to 27.2 million acres distributed over the Region as follows:

Type	Area			
		Percent of acreage		
	Million acres	N.E.Washington and Idaho	Western Montana	Eastern Montana
Lodgepole pine	6.2	25	35	40
Ponderosa pine	6.0	43	37	20
Douglas-fir	4.9	43	23	34
Larch	4.0	36	64	--
White pine	2.4	88	12	--
Cedar-hemlock-fir	1.4	96	4	--
Spruce	.9	26	44	30
Woodland	1.4	12	4	84
Total	27.2			

Lodgepole pine is of chief importance on humid and sub-humid lands in Montana. Ponderosa pine and Douglas-fir occur mainly on sub-humid areas throughout the Region, but in the Columbia drainage they also occupy considerable areas of humid land. Larch is of greatest importance in western Montana where it occupies humid and some sub-humid areas. Because it occupies much of the white pine mixture in the Inland Empire it is more important there than the Forest Survey figures indicate. White pine and cedar-hemlock-fir are characteristic of humid areas in the Inland Empire. Spruce occurs almost exclusively on humid areas and is most important in Montana, especially the western part.

b. Range:

There are about 60 million acres of non-forest range land in Region 1. Fifty-six million acres of this are in Montana. Better than half of it is sagebrush-grass and low shrub-shortgrass range in the arid plains of eastern Montana. The portion of this range of direct importance to the Forest Service is some 3 million acres of LU projects.

Of some 15 million acres of publicly-owned non-forest range in the Region, about 2.1 million acres are in National Forests. An additional 5.4 million acres of forested land are also used for livestock grazing.

From a use standpoint only a small part of the 7.5 million acres of National Forest grazed by livestock is of great importance. Of principal concern are about 1 million acres of subalpine-grass-forb range, most of which occurs in the humid areas of Montana; about 3 million acres of sedge-pinegrass-bunchgrass range scattered throughout ponderosa pine-Douglas-fir forest in the sub-humid areas of the Region; and about 2 million acres of sagebrush-grass range lying mainly in sub-humid areas of Montana and the western fringe of the Region.

D. Watershed Management Problems

Region 1 is actually in pretty enviable position insofar as the condition of its forest and range lands for watershed protection is concerned. Despite this, many questions have arisen concerning the impact effects of land use on water and soil. Rapid acceleration of timber cutting with its attendant road building is extending use to new types on steeper land, shallower soil, and areas of greater water yield. Grazing use, though it has not led to the widespread depletion encountered in some other Regions, has resulted in local deterioration in many places. It is probably safe to say that, as of now, the most important watershed management problems we have are those dealing with how to protect soil stability and satisfactory streamflow under continued forest and range use.

1. <u>Watershed Protection Problems</u>

The main objectives of watershed protection are the production high-quality water and keeping soil in place on the ground. To accomplish this we try to: (1) prevent or reduce accelerated surface runoff and erosion, (2) hold down snowmelt flood peaks as much as possible, and (3) prevent summer rainstorm "flash"

floods. Lowering of water quality can be laid to four principal causes: roads, logging, grazing, and fire. Yet all four are necessary if we are to realize full value from timber and forage resources. The conflicts between resource use and watershed protection develop because we have not yet learned to evaluate the costs of measures needed to maintain high-quality water in relation to the value of that water. Our ignorance of the balance in values involved and, in fact, of the values themselves, point up the need for increased effort to develop basic information and techniques for economic evaluation of watershed protection measures. Research's responsibility in this is large.

The more immediate considerations here today are the problems concerned with the physical measures needed for watershed protection purposes. These can be divided into two categories: (1) watershed maintenance problems and (2) watershed restoration problems.

The Maintenance Problems

On Forest Land:

Watershed Maintenance Problems	Areas of Greatest Importance: Columbia: Runoff zone	Columbia: Vegetation type	Columbia: Soil	Columbia: Priority	Missouri: Vegetation type	Missouri: Soil	Missouri: Priority
1. What are the criteria or guides for improving location, construction, and maintenance of main access and temporary logging roads to prevent accelerated surface runoff, erosion, and sediment movement into streams	H	WP	glacial silt loess granitic	A_1	LP	dolomitic andesitic	A
		L	glacial silt granitic				
	S	PP-DF	granitic glacial silt		DF	dolomitic hard sediments	
2. What are the corrective measures needed to stabilize road cuts and fills against slumping, to provide proper drainage from road and skid trail surfaces, and to control sediment movement into stream channels	H	WP	glacial silt loess granitic	A_2	LP	dolomitic andesitic	A
		L	granitic silt granitic				
	S	PP-DF	granitic glacial silt		DF	dolomitic hard sediments	
3. What are the effects of stand composition, size and pattern of cutting, amount of timber removed and method of logging on quality, quantity, and timing of spring runoff	H	WP	loess granitic glacial silt	B			
		L	glacial silt granitic				
	S	PP-DF	loess granitic				
4. What are the effects of controlled burning and dozer scarification as a silvicultural operation on water quality	H	WP	loess granitic glacial silt	B	LP	dolomitic andesitic	C
		L	granitic glacial silt				
	S	PP-DF	granitic		DF	dolomitic hard sediments	

On Range Land:

Watershed Maintenance Problems	Runoff zone	Areas of Greatest Importance — Columbia: Vegetation type	Columbia: Soil	Columbia: Priority	Missouri: Vegetation type	Missouri: Soil	Missouri: Priority
1. What are the plant cover and soil conditions required to prevent accelerated surface runoff and soil erosion	H			B	sub-alpine-grass-forb	dolomitic andesitic	A_3
	S	sage-brush-grass PP-DF-grass	soft sediments (granitic (basaltic		sage-brush-grass PP-DF-grass	soft sediments (hard (sediments (dolomitic	
	A				low shrub short-grass	(hard (sediments (glacial (silts	
2. To what extent and by what methods of management can these ranges be grazed and still maintain protective conditions for controlling surface runoff and soil erosion	H			B	sub-alpine-grass-forb	dolomitic andesitic	A_4
	S	sage-brush-grass PP-DF-grass	soft sediments (granitic (basaltic		sage-brush-grass PP-DF-grass	soft sediments (hard (sediments (dolomitic	
	A				low shrub short-grass	(hard (sediments (glacial (silts	

The Restoration Problems

Watershed Restoration Problems	Runoff zone	Areas of Greatest Importance					
		Columbia			Missouri		
		Vegetation type	Soil	Priority	Vegetation type	Soil	Priority
On Forest Land;							
1. What vegetational and mechanical measures are needed to restore eroding road surfaces, cuts and fills, skid trails, and stream banks to protective conditions	H	WP-L-S	glacial silt granitic	A_1	LP	dolomitic andesitic	B
	S	PP-DF	granitic glacial silt		DF	dolomitic hard sediments	
2. What are the comparative effects of retaining brush and of planting timber on old large burns for stabilizing soil	H	WP	granitic	C			
On Range Land:							
1. What are the grazing management methods and techniques required to restore unsatisfactory range to protective condition	H			C	sub-alpine-grass-forb	dolomitic andesitic	A_3
	S	sage-brush-grass	soft sediments		sage-brush-grass	soft sediments	
		PP-DF-grass	granitic basaltic		PP-DF-grass	(hard (sediments dolomitic	
	A				low shrub-short-grass	(hard (sediments (glacial (silt	
2. What artificial revegetation and mechanical measures are needed to restore critically eroding range areas to protective condition	H			C	sub-alpine grass-forb	dolomitic andesitic	A_2
	S	sage-brush-grass	soft sediments		sage-brush-grass	soft sediments	
		PP-DF-grass	granitic basaltic		PP-DF-grass	hard sediments dolomitic	
	A				low shrub-grass	(hard (sediments (glacial (silt	

1. Watershed Improvement Problems

Of not such immediate concern, perhaps, as the protection problems, but still of great importance are the problems of improving water yields. These problems appear to be more significant on the Missouri side of the Region. In time they may become important on the Columbia side as demands for water increase.

The main objectives in improving water yields are to: (1) increase the annual streamflow, (2) reduce yield during the high-flow season, if possible, and increase it during the low-flow or summer season, and (3) prevent acceleration of soil erosion. To accomplish this we try to salvage interception and transpiration losses and convert them to useful streamflow. As with the protection problems, there are two considerations involved here. First, how and to what extent can we accomplish these objectives physically. Second, economically how far are we justified in curtailing timber and forage production values for more water. The first of these considerations will be our only concern here.

The Improvement Problems

On Forest Land:

Watershed Improvement Problems	Runoff zone	Areas of Greatest Importance: Columbia — Vegetation type	Columbia — Soil	Columbia — Priority	Missouri — Vegetation type	Missouri — Soil	Missouri — Priority
1. What are the effects of size and pattern of timber cutting, and amount of timber removed on quantity, peak discharges, timing and quality of streamflow	H				S-LP	dolomitic andesitic	A_1
	S				DF	dolomitic hard sediments	
2. What are the effects of riparian cover removal on quantity, peak discharges, timing, and quality of streamflow	H				S-LP	dolomitic1/ andesitic1/	B
	S				DF	dolomitic1/ hard sediments1/	
1/Principally on deep valley fills)							
3. What are the effects of beaver dam construction on timing of streamflow and of abandonment on quality of water	H S	Riparian	1/	D	Riparian	1/	D
1/Principally on deep valley fills)							

On Range Land:

Watershed Improvement Problems	Runoff zone	Columbia — Vegetation type	Columbia — Soil	Columbia — Priority	Missouri — Vegetation type	Missouri — Soil	Missouri — Priority
1. What are the effects of drift fences or planted windrows for accumulating snow and delaying melt and how effective is this in altering timing of streamflow	H				sub-alpine-grass	dolomitic andesitic	C
2. What are the relative transpiration losses from sagebrush and grass range and can any increase in streamflow be realized by type conversion	S				sage-brush-grass	soft sediments and terrace	C
3. What are the effects of water spreading on deep soils on the timing of streamflow	S				sage-brush-grass	soft sediments and terrace	C

I have tried to indicate to you which of the watershed management problems appear to me to be of greatest significance and where they appear most important. It is quite evident that we are faced with a substantial backlog of problems for which answers are needed. Some of these problems require research more than others. Despite the fact that there is a substantial amount of knowledge about these problems which has been gained from experience, much of it has not been translated into useable guides. Assistance in development and evaluation of methods and guides which have immediate practical application for maintaining protective watershed conditions appears to be one of Research's first responsibilities.

Beyond this, however, Research also has a responsibility for developing methods and guides for improving water yields in those areas needing it. Solution of these problems is, at best, time consuming because of the necessity to calibrate watersheds and evaluate the effects of promising treatments over some period of years. If answers are to be forthcoming in a reasonable time, therefore, it is important that some effort on these problems be gotten under way rather soon.

The next job Research has is that of spelling out a practicable and balanced study program and getting it going. In doing this there are two major considerations of which account must be taken. One is Research's capabilities, that is, how much program can be handled with money and manpower available.

The other consideration is concerned with the Region's assessment of the relative importance of its watershed problems in relation to that I have presented. Some of you may have in mind important problems that I have failed to include. Some of you may have a different opinion as to the importance of these problems, hence, which ones should be tackled first. We have reached a point, I believe, where Administration's serious consideration of just how important each of these problems is on a Regional basis will assist materially in shaping a future program of watershed management research in Region 1.

WATERSHED MANAGEMENT IN RESEARCH

Watershed management problems and research needs in the Region 1 area

Soil survey needs . . . . C. L. Copeland, Jr.

Water problems arise chiefly from two sources: (1) improper housekeeping practices that result in the pollution of water supplies, and (2) those that occur because of improper land management. The latter problems are uppermost in the minds of you in attendance at this conference.

My subject "Soil Survey Needs" is of importance not only to watershed management but to other resource and service activities as well. And since we are constantly faced with multiple-use considerations, I should like to tae the liberty of treating this topic from a multiple-use standpoint. Accordingly, I hope to contribute, in a small way, to the further exploration of item "e" in the preface to the program--"Is our watershed management activity (or other activities) limited by technical or administrative deficiencies?"

Soil surveying activities began in the United States almost 60 years ago--just before the turn of the century. Early ideas about soils stemmed from assumptions and teachings of the great German chemist, Liebig. About 1870 the Russians developed a new concept of soils that revolutionized and gradually permeated American thinking. Boiled down, the Russians conceived of soils as natural bodies, each with its own morphology, and resulting from combinations of climate, time, relief, parent rock material, and organic matter. This new concept was responsible for soil science as we know it today. Soil classification and soil survey are research activities within the field of soil science.

When studying soils and their characteristics and predicting their potentialities, it is impossible to work with the whole continuum at once. We must recognize individual soils. At this point the need for soil classification becomes apparent. Only through the orderly process of classification can we organize our knowledge and retain it. Then and only then, do we begin to see relationships and formulate principles of prediction.

Why do we need soil maps? The most usable results obtained from forest experimental study plots are those that are correlated with defined kinds of soils. To best utilize experimental results to obtain a better understanding of soils or to predict their behavior, soils must be grouped in terms of defined units. This is the primary function of soil classification. Few people, among the many who need or want to use the predictions and behavior principles, can readily identify the soil units in the field. Thus it is essential to have maps. With maps derived from an adequate system of classification, the application of soils information becomes an almost routine procedure.

Soil mapping requires both knowledge and art. The finished product--the map--depends largely on the resourcefulness of the field scientist. This leads to the question, "Who should do the job?" Normally, for regular soil surveying, the Soil Conservation Service is the agency now assigned this function. Consequently, the major portion of effort is directed to agricultural lands. On small projects, such as proposed land exchanges, the Soil Conservation Service has indicated a willingness to assist the Forest Service in surveying. This is one line that might well be exploited more fully.

Soil surveying in forested areas or wildlands might appropriately and best be conducted by Forest Service personnel. There are several good reasons for this suggestion. This kind of mapping requires additional kinds of training other than that normally received by soil scientists. And I might add--different to that received by most foresters. Since few individuals may have the broad integrated training in both lines, soil surveying can better be accomplished by foresters and soil scientists constituting a team. Their knowledge in their particular fields would compliment one another's contribution to the survey. Field conditions or administrative organization may vary from one region to another, and as they do, the composition of the survey party should be altered as appropriate.

The principles of natural soil classification should be adhered to although field mapping techniques may vary in wildlands. Soils should be classified as to phase--type--and series. Then the derived soils information and behavior characteristics will be on a common basis and useful to all. Too often the tendency is to map for single soil characteristics, but as improvements in knowledge and technological advances occur, such maps soon become antiquated.

Four principal researches are involved in surveying. They are (1) to determine the important characteristics of different soils, (2) to classify soils according to classification units, (3) to establish and plot on maps the boundaries between kinds of soils, and (4) to correlate and predict the productivity of soils for various crops, grasses, and trees under different management systems.

According to the Department of Agriculture Soil Survey Manual, six kinds of surveys are generally recognized. They are: detailed, reconnaissance, detailed-reconnaissance, generalized, schematic, and exploratory. The first three surveys are those most commonly encountered. The terms used for the different surveys are self-explanatory. Variation between them occurs in the amount of detail included, scale used, accuracy of soil boundary plotting, use for which intended, and taxonomic units employed in mapping. One other kind of survey is gaining in popularity in forestry circles. It is the soils-vegetation survey which combines the mapping of soils and vegetation in one operation.

The soils-vegetation survey is best known from its use in California. This mapping provides information on the kinds of soil and plants and their characteristics; their location and distribution; the acreage of each; and the interrelationships between soils and vegetation. Vegetation and soils of major significance are mapped to a minimum of 10 acres. Less significant kinds are mapped to a minimum of 40 acres. The California State Legislature, cognizant of the pressing management problems in that state, has annually appropriated $77,000 to finance this program. Begun in 1947, this soils-vegetation survey has covered almost 5 million acres of land, including 800,000 acres of national forests. Present progress indicates a coverage of almost 1 million acres annually at a cost of about 10 cents per acre. Of this amount, about 8 cents covers aerial photo interpretation and field mapping, and 2 cents covers map compilation and public costs.

Another type of survey that I wish to comment on is a forest soil reconnaissance survey conducted in Region 6. Work commenced in 1950 on this cooperative project between Region 6, the Pacific Northwest Forest Experiment Station, and the Washington State College Agricultural Experiment Station. This survey was motivated by the need for soils information by Region 6 engineers, for extrapolation of research findings and for research planning by the Pacific Northwest Station, and as an extension of soils classification and survey activities by the Washington State College. It is a considerably more generalized survey than that being conducted in California, with the total costs amounting to only about one-half cent per acre. These costs are borne by the participating agencies. The difference in costs between these two surveys is tremendous. However, you must bear in mind that with an increase in detail, there will be a concomitant increase in cost. The California survey is of rather minute detail and even includes the preparation and publication of multicolored maps by counties.

What is the status of soil surveys in this Region? Of the 13 forested counties located in northeastern Washington, northern Idaho, and western Montana, normally considered as my work area, only 6 have been surveyed and mapped in detail. The first county mapped was in 1915, the most recent one in 1935. The area represented by these 13 counties is about 15.8 million acres. Of this, 30.5 percent or 4.8 million acres were included in the survey. As most of you know, however, no attempt was made to map any forest land to any degree of detail. For this reason within the mapped area, 37.6 percent was roughly delineated as scabland, rough mountainous land, rough stony land, or rough broken land.

I have reviewed numerous survey reports and have contacted the state soil scientists of all states having lands within the boundaries of Region 1 and the Intermountain Station in an effort to determine the status of completed surveys. A wide range of information was obtained. After compiling the information based on actual figures or the best estimates possible, the table showing the coverage of Region 1 was prepared.

SOIL SURVEY COVERAGE OF COUNTIES IN REGION 1 CONTAINING NATIONAL FOREST LANDS

State	Survey period	Survey type	Total area	Area surveyed	
			Acres	Acres	Percent
Montana	1921-42	Reconnaissance	55,866,880	21,288,480	38.1
Idaho	1917-55	Detailed and farm plng.	15,600,000	2,444,507	15.7
Washington	1915	Detailed	3,895,040	1,531,840	39.3
South Dakota	-	None	1,716,480	-	-
Total			77,078,400	25,264,827	32.8

The data in this table show that the total land area of counties embracing national forest lands in Region 1 totals 77 million acres. Almost one-third (32.8 percent) of the county land area has been surveyed to varying degrees of detail, but Forest Service lands were seldom included. Most of the surveyed acreage is accounted for by reconnaissance surveys conducted in Montana. To again remind you of the degree of detail obtained by a reconnaissance survey, let me quote from one of the latest Montana survey reports: "The soil reconnaissance in Montana is conducted by traversing the farming sections at intervals of approximately 2 miles and the grazing sections at somewhat greater intervals, depending upon the ruggedness of the area." How much do we know of our forest soil resources? The answer is--obviously not very much and certainly not nearly enough.

Soil surveys have many general uses. I shall enumerate only certain of the more important ones because to dwell on any of them would be too time-consuming.

1. Land appraisal--tax assessment and loan appraisals
2. Settlement of new lands
3. Guidance of prospective buyers
4. Land-use planning--irrigation, drainage, acquisition, water storage dams and reservoirs, flood reduction plans, and rural zoning.
5. Forest management--watershed, timber, and engineering activities
6. Range management--productivity, stability, reseeding
7. Engineering--roads, dams, reservoirs
8. Other uses--mining, pipe-line construction, etc.

To an administrator charged with the activities of his organization and one especially concerned with the expenditure of public funds, the next appropriate question is, "Of what value are soil surveys and maps?" Perhaps the most important problem in the field of forest soils is to determine what we have available as soil resources. How much? What kind? How is it situated? Where is it located? and What's it good for? To determine the answers to these questions calls for soil survey activities to include mapping. But the answer does not lie solely in a widespread or large scale survey program. Mapping is not a panacea for all of our forest soil problems. Rather, the answer to survey needs can be found only after objective consideration has been given to the development of an integrated, multiple-use type of survey having definite use objectives.

The need for soil survey information on forest lands, grazing lands, or wildlands is directly proportional to the intensity of management that is needed or planned for such areas. This will be dictated by both current and foreseeable needs. When I examine the future consumption estimates of forest products in the Timber Resource Review, I feel that we are faced with the need for really intensive management if we are to keep pace with the expected growing population demands. Time is of the essence and it behooves each of us to face the situation promptly and aggressively. The chart that will be passed out points out a few interrelated benefits that may be derived from soil-vegetation surveys that will be of value to the divisions listed. This is not an all-inclusive list, either as to divisions or expected benefits.

In order to utilize soil survey information to its fullest, there are many important relationships that need to be determined by research. The following list (not all-inclusive) provides examples of needed research in three of the various resource or service fields.

In Watershed Management

1. We need to determine the influence of permeability and position of soil layers upon subsurface flow rates.

2. What are the rates of water movement in the various kinds of substrata common to this region?

3. How do water storage capacities of different soils and substrata vary?

4. Can we ascertain the influence of amount and kind of rock fragments in the soil mantle relative to storage and discharge?

5. Can we determine the inherent erodibility of soils and how the manipulation of vegetative cover affects it?

6. What soil factors account for the prevalence of sheet erosion on some soils and gully erosion on others?

EXAMPLES OF SOME BENEFITS THAT MAY BE EXPECTED FROM SOIL-VEGETATION SURVEYS FOR VARIOUS ACTIVITIES

Research	Timber Management	Watershed Management	Engineering
May reveal relationships between forest types and growth and soils and topography.	Same	Same	Shows location of merchantable timber stands requiring access roads for future logging.
Permits preparation of productivity maps of species by soil types.	Same	Same	May provide information that may require modification of logging system or methods.
May provide information that permits avoiding duplication of research on similar but geographically separated sites.	May provide information that will lead to the modification of old cutting practices or to the development of new practices.	May provide information concerning factors that affect infiltration, soil stability, permeability, water storage capacity, and depth that aid in predicting discharge and runoff.	May suggest intensity and location of road networks.
May provide information that will lead to development of different cutting practices.	May indicate limitations on natural or artificial regeneration.		May furnish information on distribution and occurrence of soil material in relation to topography, soil mechanics, stability and erodibility in relation to road location, culvert spacing, fill-slope determinations, and surface stabilization.
Yields information that would favor extrapolation or extension of findings under certain soil conditions to other similar ones.	May serve as a guide in site selection for preparation and planting. May direct costly planting operations to most productive sites.	May indicate the proper division of the protection effort to steep slopes or areas where overload flow and erosion hazards are high.	May help to insure against faulty road location and construction operations.
May aid in a better understanding and interpretation of growth and site requirements.	May aid in evaluating the effects of slash burning on site quality.	May help to insure against faulty road location and construction operations.	May provide better basis for cost estimates for construction projects.
Soils information would aid in the establishment of statistical designs and analytical procedures for experimental plot work.	Shows location of merchantable stands for future cuttings.	May provide indication of required planting site preparation involving heavy machinery.	May indicate acceptable conditions for low standard over high standard roads in certain areas.

7. What factors influence water use by plants? Can any of these be regulated to reduce water consumption?
8. How do various cutting practices affect freezing, thawing, internal water movement, storm runoff, water yields, and erosion on different forest soils?
9. Do "jammer" roads constructed at close intervals on steep slopes excessively "underdrain" forest sites rendering them more difficult for regeneration?
10. What effect does the antecedent soil moisture content have on the detention of snow melt on different soils?

In Engineering Activities

1. What may be considered an allowable amount of erosion permissible from cuts and fills?
2. Do various soils tend to stabilize at different percentages of slopes?
3. How do erosion rates differ on different slopes with variations in steepness, aspect, soil material, and vegetative cover?
4. What are the best methods for preventing erosion from skid trails and haul roads on different soils?
5. How can we best stabilize raw road surfaces?
6. To what extent do construction costs differ by soil types?

In Timber Management

1. We need to correlate soil conditions with productivity, especially for use in bare or cut-over areas.
2. What soil conditions chiefly influence planting survival?
3. We need to evaluate the effects of uncontrolled fires and controlled fires that may be used as management tool on various soils.
4. Can forest disease incidence be related to soils? If so, can disease losses be predicted on the basis of soil characteristics?

For All Activities

1. What detrimental effects to soils result from modern power logging machinery? An excellent indication of soil structure damage has been reported by Steinbrenner of Weyerhaeuser Timber Company. He reported that four trips with an HD20 tractor reduced macroscopic pore space by one-half and infiltration rates by over 80 percent on two dry soils. One trip with the same tractor caused the same damage when these soils were moist.

SUGGESTIONS: I have attempted to review briefly the extensive subject of soil surveys during the past few minutes. Assuming that at least the highlights have been touched upon, there are a few specific suggestions I wish to offer.

1. I suggest that favorable consideration be given to ways of implementing soils-vegetation surveys in this region. A soils-vegetation survey in my opinion offers numerous advantages over a regular soil survey.

2. The figures I have available, as to national forest land in Region 1, show a total of 24,705,472 acres. This is divided approximately as follows: Commercial timber area available for management, 13.4 million acres; range open to livestock, 6.7 million acres; wild and wilderness areas, 3.5 million acres; natural and botanical areas, 4,000 acres; experimental forests and ranges (active and inactive), 28,000 acres. A soils-vegetation survey of considerable detail would cost about 2½ million dollars, figured at 10 cents per acre. A reconnaissance survey would cost $125,000, figured at ½ cent per acre. But is complete survey coverage needed? It is doubtful that it is until correlations of research findings and well-founded observations can be made with soils information to aid in interpreting these relationships.

   Therefore, I suggest that survey activities be first confined to experimental forests and ranges, permanent study plot locations, and even road networks where complete costs and maintenance data are available for study. These surveys should be detailed and would cost about 10 cents per acre. For all experimental areas, the total cost of surveying would be only about $3,000. As soil correlations and related predictions are derived, then surveying should be extended to other areas in any detail desired to permit application of the known correlations.

3. Any forest surveying program contemplated might well be conducted by a team consisting of a soil chemist, forester, and engineer. Advantages of organizing a team of this composition are quite obvious.

4. Interest in promoting forest soils work in this region has been indicated for a long time by many individuals. Unfortunately, progress towards establishing such work has been exceedingly slow. With a total land area in Region 1 of about 117 million acres, Forest Service lands of about 25 million acres, and a population of more than 1 million, the impact of forestry on regional and national economy cannot be ignored. But the medium for the existence and growth of the forests--the soil itself--has not received its deserved study. When are we to realize that without adequate soils information, in whatever division you choose, applied management practices resemble, somewhat, an attempt to effect a cure without first knowing the cause.

   In view of the paucity of forest soils information on a national scale and especially in our own region, I would like to suggest that consideration be given to the establishment of a soils division or specialist on regional and station staffs to provide service for all divisions, comparable to that of an editor, statistician, personnel manager, or engineer. I make this suggestion with the sincere conviction that expenditures for soils work will be returned many-fold.

   Thank you for affording me the opportunity of discussing this subject and for your kind attention. I hope I have helped to explore the question, "Is our watershed management activity limited by technical or administrative deficiencies?"

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of points of conflict and areas for coordination between Watershed Management and Timber Management....A. G. Lindh

During my first month as Division Chief in Timber Management, Major Kelley, then Regional Forester, wrote me a note asking that we do something to stop soil erosion and watershed damage occurring as a result of timber sales. I began drafting a circular which was sent to the field February 28, 1944. It asked for comments and suggestions by March 20. It required immediate use of an erosion prevention and control clause. I will read the initial paragraph and the policy then set up:

> Truck and tractor logging methods in steep country produce intolerable erosion and stream-clogging conditions. This has been discussed by forest officers for years and some efforts to reduce the damage have been made. Nevertheless, the damage continues and in many areas is growing worse as the size and power of logging equipment increases.
>
> It is apparent that we are not redeeming our responsibilities for the management of national forest land, for the prevention of damage to adjoining lands and for the protection of downstream values far removed from the area logged.
>
> It seems clear that the prevention of soil and stream-channel destruction resulting from the harvest of the forest crop ought to be a required part of the logging operation. The best present estimates of the cost of this work may fall short of actual needs; however, for a start, 10 cents per M is set up as a legitimate charge against total volume removed. All the cost may be placed against the principal species in the appraisal.
>
> The policy proposed follows:
>
> The harvesting of timber carries with it an obligation to prevent deterioration of the site and to minimize damage to adjoining lands and downstream values. The expense of preventing excessive soil erosion and stream damage is a legitimate item of logging costs.

The response to this circular was good. There is a voluminous file of material. I would like to quote from certain of those replies:

> In this particular instance of erosion control, we are resorting to a contract clause to overcome an evil which should be corrected by sale area administration. Specifically, the first sentence of clause 20, in all 202 Timber Sale Agreements, reads in part, "That all structures and improvements shall be located and operated subject to such regulations by the Forest Officer in charge as may be necessary for the protection of National Forest interests." It seems to me that the above provision clothes the Forest Officer in charge with sufficient authority to approach an operator, explain the purpose of erosion control, define the necessary corrective measures and expect adequate compliance.
>
> I do not approve of the mandatory requirement of inserting the clause you have prescribed because:
>
> (1) Our sales contracts are already overburdened with clauses and stipulations, many of which are not pertinent to the particular sale, and which in the aggregate make up a document that is as formidable, confusing, legally intricate, and as little read as an insurance policy. Our operators rely absolutely on the Forest officer for interpretation of the contract and are willing to meet all reasonable requests and suggestions. In this spirit we have succeeded in affecting a creditable job of logging on our sale areas.
>
> (2) At least three-quarters of our supervisor's sales are either on flat ground or on areas that have been logged before, where roads are already in place, or where chances of harmful erosion are negligible. We have practically no tractor skidding on this Forest, consequently no "cat" skid-trails on steep slopes to cause gullying.
>
> The draining of roads can be simplified by breaking grade or leveling out at reasonable intervals depending on soil type. This system is more or less self-draining and would leave the road in usable condition.

Five years later, I was asked by the Chief to prepare a paper on the effect of sales on water runoff and what comprises are necessary or desirable in sales planning. Preparatory to preparation of that paper, I requested forest officers on the national forests and in the Research Station to draw upon the five years of experience to advise me on what should go in that paper. That file is indicative of the growth of both the knowledge drawn from experience and the frustrations from having too little control over the elements affecting erosion and from the lack of any real factual information that would help firm up the planning and administration of erosion prevention work. The paper was prepared and

delivered. I will quote from a few of its paragraphs to indicate the type of material then accepted by the Chief as a general guide for the development of national guides which for the most part remain in effect.

> As we cut into the rougher terrain of the upstream watersheds we run into tougher and more important problems in the prevention of damage to streams and water flows. Water yields increase as cutting goes up in the mountains. What are the effects of timber cutting, road location, road standards, skid trails and landings? No one really knows the score. Not enough attention has been directed to these subjects.
>
> It may well be that as a part of watershed management, manipulation of vegetative cover through timber management practices and otherwise can be deliberately made to contribute significantly to producing water in volumes, timeliness and quality needed to meet some or all of the varying requirements of individual subdrainages. Reduction of flood peaks may be an objective in one subdrainage but not in another. Delivery of more water for storage may be needed in one but not in another. Gradual delivery of maximum possible flow in August may be the need in places.
>
> Whether and to what degree local needs can be met through timber manipulation must be more clearly determined and the needed arts of timber manipulation spelled out before timber managers can move with assurance to adjust timber cutting practices to make water flows better.
>
> However, I feel strongly that for the present we should direct our efforts to find out if we can use the timber without materially changing streams and water flows on a working circle basis. In other words, let's not try to manipulate water until we have learned how to harvest timber with minimum effect upon water. If we can do this we will not change existing natural water movement. We will incidentally contribute to knowledge on how to deliberately manipulate timber to create bettered effects upon water yields. Perhaps, also, in the meantime, research in the science and art of manipulating vegetative cover for positive ends will have progressed to the point where proven tools of management will be available.
>
> I want to make it clear, therefore, that my presentation is aimed solely at minimizing the effects of logging and timber cutting upon water and its existing natural regimen - to assure as nearly as can be the status quo of present water yields and their characteristics.

Within a single small drainage as much snow and precipitation per acre will usually fall on the south slopes as falls on the north slopes. Yet, the south slopes are entirely or partly bar before the stream increases its flow in the spring, indicating that most of the increase in water flow during the spring melt comes from north, east and west slopes. No one has answered the question as to where this snow, which falls on the south slopes, goes to.

No one knows just how much the peak of spring melt and run-off is increased by cutting. Probably we will find that it varies with each sale area. More attention to the behavior of snowfall and melt is needed. It would be very desirable to have small streams gaged for a few years before cutting so that the hydrology of the drainage could be compared pre and post cutting. As a minimum, we certainly need to have a considerable number of sample streams gaged so that local forest officers can begin to obtain local data needed for sale planning and administration.

General observation of silting, stream spoiling and erosion of roads and skid trails after a timber sale operation indicates a need for a considerable number of adjustments in timber management activities. For the most part, we are forced to make a calculated guess as to what preventive measures to take.

The simple measures so far designed have been partly successful. The degree of success depends upon a lot of factors and many mistakes have been made. One of the most important mistakes has been that too often skid trails and roads have been located in or adjacent to natural drainage channels. Where this has happened, there is no way to avoid serious damage. In a few instances check dams built in natural drainage channels, which had been invaded by roads or skid trails, have compounded the damage as the check dams cumulatively washed out in flood times.

In other instances slash has been thrown crossways in skid trails and roads to form silt dams and water diverters. Only a part of this work has appeared to be effective.

Another measure was to avoid damage to the stream channels through burning after logging. This required keeping the fire away from the stream and keeping the burned spots to a minimum along the streams. Further emphasis was given the location and drainage of truck and skid roads to prevent abnormal soil erosion. An aim was to hold down the grades of skid and truck roads to minimize potential soil washing.

The evidence strongly indicates that most timber cutting tends to increase the volume of water which runs off cut areas during spring flows. Even where adequate road drainage is planned on the basis of apparent need for it, as determined by the sale officer in advance of the sale, it is believed that one weakness in our planning has been failure to anticipate the increased run-off which tends during the spring melt to heighten the peaks

of permanent streams and to develop new seasonal streams.

We may have to increase culvert size to insure adequacy 50 percent or more beyond the greatest capacity requirement of which there is advance evidence.

It is a common practice in the construction of highways and even our own main roads to relocate or channelize portions of streams adjacent to the new roads. Normally, the new channels have steeper gradients than the original. As a result, there is always increased washing and cutting in the new section and the silt, gravel and debris cut loose is then deposited in the virgin sections of the stream, gradually raising their elevation. This disruption of the natural regimen of a stream developes raised points where annual damage from flooding the road threatens.

Leave a minimum streamside strip of from 100 to 200 feet in width on each side of each channel that carries water during peak flows.

Within that streamside strip log very lightly. Haul trees away from the stream and skid with horses or winch to a cat or truck road located outside of the streamside strip. Keep slash burning in the streamside area to the smallest practical spots.

Keep roads out of the streamside strip except for necessary wellplanned crossings. Do not "pool" the stream in making crossings.

Clear cutting as a silvicultural method is compatible with watershed management. The size of the area that may be clear cut is an unknown from the standpoint of effects on the nearby stream. It probably varies with soil, slope, amount of humus, logging debris, amount and kind of precipitation. Generally speaking, in lodgepole we have tried to keep clear-cut areas to 75 acres or less but we are not certain that this limitation is correct. Some of the foresters handling the clear-cutting sales believe that in certain areas the clear cut should be larger. Some believe the clear-cut areas should be smaller.

In timber types that will stand up and be of value after logging, it appears that light selection cutting is desirable from a watershed standpoint. Effects of cutting methods need to be better determined.

White pine management requires clear cutting of natural burning units and the management of a white pine unit must be controlled

primarily to minimize the cost of preventing damage by blister rust. The main reliance here to prevent silting of streams and stream damage is being placed on leaving streamside strips of tolerant species, such as hemlock, cedar, spruce and grand fir. Burning is followed by planting.

The slash treatment method which assures quickest regeneration of the desired tree crop is apparently the best since the tree cover is primarily relied upon to protect the watershed.

Specific positive planning of slash treatment is needed for each area.

The available evidence indicates that disruption of natural stream channels through skidding, road building, and allowing logging debris to accumulate in the stream are of greater importance than the cutting methods in the effect on the watershed. All evidence indicates that the location, standards, drainage, and maintenance of the transportation system most urgently require improvement. Alert and constant effort is required to prevent erosion.

Logging methods likely are also more important than the kind of cutting being practiced. The principal variant in logging methods is the method of moving a log from stump to truck. This, in turn, affects the kind and frequency of truck roads.

Until carefully controlled experimental logging proves it's safe, stay off steep ground. How steep ground can we log? There are many varying factors to weigh on each individual area. Until we're sure, let's keep off the doubtful slopes.

Some of the best water for trout is at the headwaters. Trout may not inhabit the upper reaches and yet be critically affected by what is done there. The watershed lands are regarded as the most important component parts of trout streams. Natural reproduction of trout is far the most important means of restocking. This means that each trout stream is its own fish hatchery. The degree of silting which will prohibit hatching of trout eggs has been determined, at least for some trout species. It takes very little silt to destroy fertilized eggs. This is one of the factors which should strengthen recognition of the need of both care in logging and the use of streamside strips of 100 to 200 feet wide.

In some instances grass has been seeded in skid trails and in areas where other palatable feed is scarce. Cattle are attracted to such skid trails and through trampling in wet weather they have, in some places, nullified much of the erosion control work through trampling drainage ruts through water

diverting dirt barriers. Grasses that form heavy sods interfere with, or even prevent, the timely establishment of natural tree reproduction. It is believed that where grass is used on timber sales for retarding run-off and retarding erosion the species of grass should be nonpalatable. Furthermore, in areas where you want to get tree reproduction, any grass which may be needed temporarily should be nonsod forming. Sod-forming grasses are recommended for seeding on dirt roads which are desired for permanent use and on landings which may be used in the future. If stock can be excluded while grass is being extablished, the species used should be palatable.

Following return from that meeting, the paper was transmitted to the field. There was an invitation to comment upon it. The response to that invitation was very meaty. The materials have not been analyzed by anyone in an adequate manner.

About that time I was included in a "jury" called to Fraser, Colorado to examine the plan for a study of the effects of logging upon a small drainage. The plan basically contemplated putting in a typical road system as an immediate forerunner of a silvicultural plan which had been thought through and designed with extreme care. This appeared to me to be quite ridiculous since the preponderance of all our evidence indicated that the heavy damage was in physical disturbances of soil through the construction of roads and skid trails. Accordingly, I strongly urged that the plan be revised. It was suggested that there be designed a road system just as good as was possible drawing upon the skills available, with the objective of doing minimum damage to the watershed. This road plan would be placed in effect and allowed to remain in place without any logging until the effects of road building had been fully calibrated. Only after that was done would there be the beginning of a carefully controlled logging job, designed primarily to determine the water flow effects of the removal of vegetation of successfully larger percentages of this watershed. This proposal was adopted, and, as I understand it, it is being carried out. When the results are available we will begin to have the first real factual material that can measure qualitatively and quantitatively the effects of removing vegetation by logging. We will also, I think, be able to determine the minimum influence of the construction of a road system.

During October 1950, Hans Roffler made a study of the erosion effects of a timber sale road on the Lost Block on the Coeur d'Alene. There is excellent material in that study. It was transmitted to the field June 1951. In October 1950 I prepared a memorandum on the relation of forests to our water supply for Russell Croft of the Intermountain Station. There are some items here that I would like to quote.

At a TM meeting in Portland I presented a paper on "Effect of Sales on Water Run-off and What Compromises are Necessary or Desirable in Sales Planning." This was sent to our field folks for criticism.

We can selectively log our water course and streamside strips provided trees are carefully selected, felled away from the stream and winched away from the stream course. Careful cleanup of logging debris is essential.

We have two basic logging methods. The first and most common is "cat" skidding with very large crawler type tractors. Tractors usually stay on the cat roads and haul the logs to the road with winch and cable. The average square mile of this type of logging requires 5 miles of truck hauling road 33 feet wide and 16.7 miles of "cat" road 22 feet wide. Widths include bank, roadbed and fill. Thus approximately 3.1 percent of the land area is in truck roads and 7.0 percent in "cat" roads. Variation in truck roads probably does not usually exceed one percent either way from the average. "Cat" road area varies more. How much has been only roughly estimated, but from my observations will say from 5 percent minimum to 12 percent maximum. As percentage in cat roads drops there are more "cat" tracks off the prepared roads.

This scheme of logging on national forest land aims to obtain cat roads under 25 percent gradient in the least erodable soils and under 10 percent in more easily eroded areas. On national forest sales, drainage after logging at frequent intervals is obtained by outsloping and diagonal ditching of all cat roads and truck roads not supplied with permanent culverts.

The second basic method uses a mobile "jammer" which operates from a truck hauling road.

Jammer logging is usually supplemented by horse or small tractor skidding from the "long corners." Truck roads are spaced from 350 to 600 feet apart. Almost all the timber is skidded uphill. Only the trees adjacent to the upper side of the road are skidded downhill. Truck roads are about 33 feet wide including bank, roadbed and fill. It is estimated that on the average 8.3 percent of the land area is in roads. There is considerable variation, probably from 6 percent to 9 percent.

Under the jammer system the majority of the roads are on the contour. One out of 4 or 5 will lead downhill usually at 8 percent grade or less. There are no skid roads or trails. Hardly any evidence or skidding disturbance of soil is found between jammer roads.

You understand that clearing is somewhat wider than the area disturbed by grading. I am enclosing a report by Roffler on the Coeur d'Alene covering a study of a considerable area of jammer logging. He notes that the only erosion found was where there was culvert failure. This checks with my observations in a number of areas.

The "cat" skidding method is harder to keep under control and the "cat" roads are difficult to adequately drain. It can be done with very little washing or apparent movement of dirt by water. Success depends on making a properly designed layout of roads in the beginning and on proper follow-up after logging to prevent water concentration by outsloping and adequate drainage. On the other hand, we have some rather horrible examples of drainage failure and quite a few examples of failure to install drainage. We have not given up hope of getting on top of this problem which is largely one of know-how and administration. Much progress has been made in the past few years.

On slopes of 30 percent contour roads cut 4 or 6 feet into the soil mantle (or is it rigoleth?). While our slopes probably do not average 30 percent there is so much of our watershed timber on this kind of slope that it is a fair sample. With jammer logging the mantle is cut on the contour every 400 feet on the average. In the spring, water bleeds out of the uphill bank, runs across the road and has 400 feet to sink before another road cuts across. Except for the roadways, there is no apparent change in surface flow.

Our knowledge of hydrology as affected by logging is so uncertain and limited, especially when applied to specific areas, that we must judge largely by visual evidence such as soil movement and sediment or lack of it in the stream below.

Several of our timber sale men report lower spring crests after logging than when the drainage was entirely covered by virgin timber. They believe the change is caused by earlier melting in the cutover areas and that this produces high water a little earlier with the same or perhaps even a larger total run of snow melt water but spread over a longer period. I wish we knew.

I doubt whether we need any large area of permanent protection forest beyond the vast areas of high country where soils are thin and very steep. We have 50 percent of this region in that category now, placed there by small volumes per acre, inaccessibility and extremely short logging seasons. By the time we work uphill to those areas, we will know enough, from experience down lower, to permit the next generation to make sounder decisions than we do now.

I would favor a policy which said "Thou shalt not make even a little gully nor shalt thou permit national forest sediment to dirty any stream." It's amazing how we can think up new ways when we have to.

In 40 years we have logged less than 10 percent of that half of the national forests which is classified for commercial timber use.

We would like to determine the effects of jammer logging and "cat" logging methods on the hydrology of several sample areas. If you can give us any leads or any kind of help we would surely appreciate getting them. We have several logging outfits with a half million dollars plus in logging equipment. To get them to change to another type will require some potent ammunition.

At the present time it is my strong belief that Timber Management has more factual material available in the Regional Office and on the forests to guide current administration of timber sales than is available anywhere else. Our Region was the first to attempt to do a positive job of erosion prevention in the planning and administration of timber sales. During the years of developing methods we have had some excellent help from Baudendistel, from Meyer Wolff, and from Fred Johnson. We have had relatively little help from Research. A few years ago we spent much effort in making a joint plan with Research to study the effects of timber utilization in Pinkham Creek. Through changes of organization and personnel and the onslaught of the spruce bark beetle, these plans were not carried out. We have had resistance from many sources, including members of the logging industry and many of the engineers who have only recently really begun to develop an understanding of some of the effects of road construction. We have had a great deal of criticism from sportsmen saying that we were not doing enough. Much of this criticism is merited. We have had criticism from many others. Much of it also is merited.

Everyone concerned with the problem should be concerned how to most constructively use his efforts to get a better job done. Some of the most important jobs to be done are:

1. We need an adequate research program keyed to the use of the forests for timber production. This study would encompass both the road building and crop removal effects. This study should not be approached negatively. They should be comprehensive and attempt to evaluate the plus and minus effects.

2. We should have a concurrent study of logging methods. Our spur or feeder roads, whether for use by jammer or skidding tractors, should perhaps be on the contour. If this were done only 1 road in 4 or 5 would be done here. It would be located and constructed as a permanent addition to the system. If the studies are competent they will probably deal in the economics of logging as well as in the effects of the methods upon the forest and the water.

We need the constructive assistance to get facts from everyone who can help to supply them. The time is past when we can afford to deal with this important subject on the basis of individualistic opinions, or on the basis of fragmentary study data from soil, forest, and water conditions far removed from the area.

3. As an objective we should gauge one small drainage on every ranger district within the next 5 years so that we will accumulate pre- and post-cutting water flow data on a local basis. We not only need facts, but we need to be able to prove that we have them.

4. We have excellent sample case study material available for empirical studies now. For example, Jumping Creek has been subjected to road building and patch clearcutting in lodgepole. The percent of the area cut is greater than we propose to cut in Moose Creek, which is in adjoining drainage. It is my guess that in two days, visual observation could pretty well determine how much damage was caused by road building and by logging in Jump Creek. The information, if obtained by a trained observer, would undoubtedly be better to use as a guide in Moose Creek than the present research data available from other sources.

5. I believe that the Timber Management activities largely through sale contracts can be improved by firmer administration of the sales. Firmer administration cannot be supported under serious appeal on high cost innovations unless we have real facts to prove that it is in the interest of the Government as well as contemplated under the appraisal for the timber.

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of points of conflict and areas for coordination between Timber Management and Watershed Management...D. J. Kirkpatrick

(Paper prepared for the Watershed Management Conference, Denver, Colorado, 1955, read by E. F. Barry)

As the utilization of the national forest timber resource progresses and becomes more intensified, we as managers have and will continue to have increasing opportunities to manipulate forest cover in the interest of water production, timber production, or both. But to do so we need to know where we're going. My assignment here is to enumerate points of conflict in the management of these two leading national forest resources. Some of the things I see as possible conflicts may not prove to be conflicts at all, once sufficient research has been directed to water-timber cover relationships in our various forest types and climatic zones, and of course others may develop which I cannot foresee.

In discussing this subject I have divided the problems into two classes--those which exist or may exist on multiple-use areas, and those which exist on single-use areas.

As to this last classification which I will dispose of first--the basic conflict exists solely by reason of the single-use designation. The problem is that timber management activities are excluded from significant areas of national forest timberland for the purpose of protecting domestic water supply sources. The prime example of this single purpose dedication of timberland is the Bull Run Watershed from which Portland gets its water supply. Here four billion feet of timber are locked up in a virgin timber watershed reservation of 138 thousand acres. In sharp contrast, in the same climatic zone and timber type is the City of Seattle Watershed in Cedar River where timber management has for years proceeded apace without demonstrable ill effects on the Seattle water supply. These two cases serve to focus attention on an important area for correlation of watershed and timber management philosophies and attitudes--and they are by no means isolated. Problems of the withdrawal of timberland from use for timber production in the interest of protecting municipal water supplies exist in all national forest regions in the west and involve in the aggregate an extremely large acreage of land on which the single use dedication is of highly questionable validity.

On national forest timberlands available for multiple use management, the points of conflict between timber and water use are often not clearly defined because of inadequate knowledge about the relationships of trees and water. From where we stand now, however, this is the big field, as I see it, for actual or potential conflicts between watershed and timber management interests. The maximum quantity of quality timber probably cannot be produced on most forested watersheds concurrently with the production of the maximum quantity of high quality water.

Until these things are done, it will be difficult to uproot the well-established and comfortable Forest Service philosophy that full timber production and full water production from the same area are compatible. This, as I see it, is the real challenge that faces Forest Service research and administration alike in going forward in the water-timber production field.

Another general area of conflict between watershed and timber management which is really of secondary character in the over-all picture, is now receiving the major share of administrative attention under the label of watershed management--viz., erosion control on logged areas. During the past several years there has been accelerated interest in defining and developing solutions to the problems that are created in the development of timber resources and the logging of watershed lands. There are clear conflicts here between watershed protection and timber interests to be sure but they're not of an insurmountable nature. In fact, we have come a long way in meeting these problems in the very brief time since they were identified and official emphasis was directed to their solution.

In summary, I can identify three broad fields in which watershed and timber management interests do or will conflict:

1. Extensive areas of watershed land in the national forests are locked up for watershed protection alone; timber management is excluded. Solution to this problem is critically needed.

2. The real big area of conflict is not yet clearly defined and will not be until more water research is done--until more economic attention is given to the relative values of water and timber yields from watershed lands. This field is in need of the best and most concentrated effort that the Forest Service can muster. The problems of use coordination between water and timber are expected to be most complex.

3. The correction or elimination of logging and logging development damage on watershed lands is a final field of conflict in the administration of water-timber resources. We are well on the way to the solution of this one, I believe, and can go the rest of the way without earth-shaking adjustments in our timber use programs.

Beginning with the very earliest watershed research participated in by the Forest Service--that at Wagon Wheel Gap in 1913 and continuing through the Coweeta studies--those at Frazer and at other points--the evidence has without exception pointed to the fact that the removal of forest cover increased stream flow. In some situations the amounts were small, in others they were very significant, but always there was an increase--and the increase was not necessarily accompanied by a deterioration in the water-yielding characteristics of the watershed.

In spite of these indications, managers of both timber and water in the national forests have gone along generally accepting as a basic philosophy: "What's good timber management is per se good watershed management." I submit that the time is near at hand, if not already upon us, when we must scrutinize this concept. As the demand for the production of water goes up, as it inevitably will with an increasing national population and the advance of civilization, the conflicts between the use of lands for the production of water and timber may well be numerous and complex. And much as I dislike to say so, I think that when the chips are down and one of these important uses must be made subservient to the other, it's water that we will place in the superior position--particularly in the West.

This proposition impinges rather strongly upon that time-tried and useful Forest Service concept of multiple use--which in public acceptance has come to mean that a given area of land can be managed for the maximum production of all good services that a forest can afford--wood, water, wildlife, recreation, and forage. If now or soon we come to the place where we must say: "We need more water--research has shown that the best way to get it is to grow only a half crop of timber in this working circle. Henceforward we are going to be satisfied with half a crop;" it looks as if we'll have to redefine multiple use--to ourselves and then to the public.

Before issues of timber production versus water production can begin to be resolved, however, I believe we have some things to do:

1. We will need to develop a defensible dollar value for water so that there will be a common denominator for weighing the relative importance of water and timber on any given watershed.

2. We will need a clear expression of what is wanted in the way of water from each working circle or major timberland drainage. Do we want to control floods? Do we want to produce the maximum yield of pure water? Do we want to maximize water yield during a specific season of the year? Do we want maximum yield to be caught in downstream storage reservoirs even at some sacrifice in quality, or is the recharge of underground storage the objective?

3. We will need continuing and expanded research of a nature that will tell us how to manipulate timber cover to accomplish the desired objectives and what quantities of additional water may be expected from such manipulations.

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of Points of Conflict and Areas for Coordination between Timber Management and Watershed Management. . . . .E. F. Barry

Mr. Kirkpatrick has pointed out to you the general fields wherein watershed management and timber management inter-relate, and the major areas of conflict on watersheds where determinations are now or will be required with regard to which resource, whether water or timber, will receive preferred treatment for maximum production. I thoroughly agree with the points raised by Mr. Kirkpatrick and deplore the situation that he mentions with regard to single purpose use on certain municipal watersheds. However, I feel assured that when we have mastered the intricate relationships which exist between logging and water production for domestic use it will become more commonplace for the production of timber and water as a joint venture than is now considered appropriate in some situations.

I will approach my share of this presentation by pointing out how I think conflicts between watershed management and timber management may be minimized, and indicate the areas where emphasis is needed to clarify or strengthen present situations. In doing so, I wish first to consider means for strengthening understanding and attitudes which, if accomplished, would aid in reducing conflicts between the harvest of timber products and watershed considerations.

One of our first needs is to arrive at a clear understanding of watershed management terms and determine what phases of watershed management are of primary importance as an associated matter of interest in the timber management activity.

There has been much discussion about watershed management which I suspect was really meant to refer more particularly to watershed protection. I believe that we should look at the watershed from the viewpoint of land use and determine what resources or combinations of resources of a watershed we may desire to produce on a given area such as primarily grass on one part, timber on another, wild land scenery, game, etc., as the productivity of the land may dictate. Another product of primary importance may be water. If water is to be the primary product, certain vegetative manipulation will be in order. I regard water production, or water delivery rate control as specialized resource products or services for which watersheds can be managed, but in Region One these products or services are still in the future, although much thought and speculation has been given regarding how watersheds may be managed to accomplish empirical river regulating programs. In other words, it appears to me that too much abstract thinking has been devoted to one or more phases of managing water as a product of watersheds without giving sufficient attention to the intricate problems that must be understood in protecting watersheds that are now being managed primarily for timber, grass, or game production.

In the field of timber management I believe our chief concern is for watershed protection to insure that damage to streams is limited and minimum soil is displaced through surface or gully erosion.

I would hesitate to recommend a reduction in the influences aspects of watershed management work if funds can be found to give more attention to the watershed protection jobs that need doing, but I feel sure that the watershed protection phase needs greater concentrated effort if we are to manage our watersheds properly for timber without the possibility of damage to the soil or stream courses in and adjacent to sale operations.

With those introductory remarks, aimed at emphasizing wherein correlation between timber management activities and watershed aspects seem required, the following appears to me to be essential.

Top management must give proper emphasis to Forest Service responsibilities for protecting national forest watersheds. In my opinion, the field of watershed protection has had too little attention, except possibly in the field of fire control. Damages on logging areas have not been adequately appraised as a watershed impact. Research has been disjointed and protective measures generally recognized and applied following some spectacular, horrible example, or at best through hard learned experience gained from a series of obvious mistakes. There has been a great tendency to demur because Research hasn't prescribed guidelines. Here again there has been confused thinking with respect to watershed management and watershed protection, and as a result watershed protection has suffered. I believe that there is a great amount of knowledge on watershed protection that could be translated into working guides if a program to do that job were decided upon. Attitudes at the watershed level tend to be influenced by considerations of precedent, costs of operations, and lack of appreciation or understanding of what needs to be done as well as how best to apply needed controls or limitations on sale areas. There has been much improvement in recent years since more attention has been directed to watershed protection matters of a specific nature, due in large part to stream damage and effect on fish habitat, resulting to a considerable extent from logging activity in high mountainous areas where erosion is likely to be a serious problem unless care is taken to alleviate it.

I believe that rangers and sales personnel are willing and anxious to log without damage to watershed values. However, they have been and are now handicapped by inadequate guidelines which should give proper emphasis to watershed protection and bring the complex measures required for planning and executing a well correlated sales-watershed program to a healthy conclusion. At this point it should be stated that financing for sales administration is insufficient to properly plan and supervise sales activities to insure that watershed values are protected. Too many instances are encountered where rangers or sales personnel find that their plans for skid trail locations, landings, etc.; have not been followed due to inability of the Forest

Service personnel to be present enough of the time while sales work is being carried on. In some cases, operators probably take advantage of intermittent supervisory visits and take liberties that are later explained as due to lack of clear understanding, but in too many cases the operators are left too long between visits by sales officers and pretty much to their own devices with regard to how sale areas may be developed for logging. If the proper supervision of sale areas is to be given to insure that watersheds are not unnecessarily damaged, it will require more sales administration money as well as more training and better guidelines for the younger men in our organization who, by the way, have the responsibility for a considerable part of the on-the-ground sales supervision.

Erosion control provisions on sale areas should be as much a part of a logging operation as slash disposal. Sales personnel need to align their thinking in this respect so that watershed protection receives its proper consideration as a part of timber sale appraisals. Well planned sale improvements are without doubt of much greater importance than corrective measures that may be required to prevent erosion on roads or skid trails. Corrective measures are too often given as one dose without adequate follow-up or, as too often is the case, are not installed at the proper time. This later results in many instances where operators are to do the erosion control work but find it inconvenient because of having moved to another area before the planned erosion control work can be performed. In many instances, much better results would be obtained if Co-op. funds were collected and the Forest Service did the erosion control work, keeping in mind that follow-up action will generally be required.

Guidelines are needed for judging probable impact upon the streams in and relatively near prospective sale areas. This will involve bridge and culvert design as influenced by greater water flows from the sale areas.

Guidelines are needed regarding the relative stability of stream beds and stream banks beginning with the solid rock of some stream beds and progressing through large boulders or rubble stream bottoms to gravels, silts, etc., giving suggestions as to what damage may be expected should roads or skidding operations be permitted to encroach on the stream banks or stream beds of streams having certain stability characteristics. Better understanding in this field is needed for intelligent stipulations in timber sale contracts. When this field is better understood there will no doubt be less likelihood of general clauses in sales contracts such as "no skidding will be permitted within two chains of stream courses."

In like manner watershed slopes should be classified as to stability on the basis of soil material, angle of repose, exposure, rainfall influences, etc., so that timber sale planners have something more than personal hunches regarding how much disturbance a given site may tolerate without serious results. In other words, it should be possible to rate prospective sale areas to indicate the degree that they are resistant to erosion. I have thought that a meter could be devised for use of this nature.

Sale planners need encouragement and backing in zoning sale areas with respect to permitted road construction, type of skidding, and exclusion of areas where logging disturbance would be dangerous from the standpoint of watershed protection.

Sale planners must assume greater leadership in specifying how and where roads will be built and the general sale area developed for logging. This field is of vital importance in my opinion, since the new sales contract gives more freedom to the logger with respect to road specifications on logging areas in face of the fact that Forest Service land managers are required to prevent land damage resulting from the logging activity.

When the soil stability characteristics of a sale area are understood so that prescriptions can be determined for road and skid trail locations, sales managers should make use of aerial photographic plotters whenever aerial photos are available. By methods now known it is possible to locate roads quite accurately from aerial photos of a given area in a fraction of the time required to scout and run lines on the ground.

Guides should be made available for sales administrators listing both good and dangerous practices on the following subjects, as well as many others:

1. Gradient limits for various soil conditions.

2. General layout favored for water and soil control--contour roads to a climbing or descending main road with jammer skidding favored, such as is covered by Report on H. J. Andrews Experiment Station by Roy Silen.

3. Proper culvert installations and why.

4. Proper surface drainage and why.

5. Dangers of borrowing from sides in fill sections on side slopes.

6. Clearing and how it can be used to intercept silt.

7. Road location guides for cat-skidded areas--location of landings so that cat trails can be drained before leading water to concentrated points.

8. Limiting cat skidding to slopes where damage won't be serious.

9. Use of Swiss Hi-line skidding for unstable grounds.

Training. Training is needed throughout the organization to arrive at a mutual understanding as to what is acceptable and what is watershed damage. Field seminars are very effective since all are able to view a given problem from a common point.

A pocket guide on watershed protection on sale areas would be very helpful for new men assigned to sales administration. It should be profusely illustrated.

We need to be careful in our writing and verbal discussions regarding how the Cedar River watershed is logged without damage to the water used by Seattle, unless we point out that the lake serves as a safety valve to settle out silt plus the fact that soil and topography tend to minimize the silt problem. We have a similar situation on the Clearwater River branch of the Blackfoot where clean water comes from the logged areas and dirty water joins it coming from an area never logged and having no large burns for 20 years or more.

Protective measures to limit or reduce erosion on sale areas following logging need to be closely related to each area, considering slopes, soils, type of road layout, skidding methods, etc. How best to drain and protect roads that are to be used for fire control purposes and when and where to seed exposed slopes or landings all need to be spelled out.

Areas of Responsibility. Under present organization concepts, insufficient emphasis has been placed upon the responsibilities of functional resource managers for watershed protection. Too many specialized resource managers have been thinking in terms of the over-all watershed management field while overlooking the important job of insuring against watershed damage resulting from poor practices within a given resource field of activity. Much good should result from a psychological realignment regarding who is to give attention to the various phases of watershed management.

In final summary, I must repeat that watershed management for water control is important in many places throughout the country today, but in most places I feel that greater effort is needed to insure protection of the watersheds from serious impacts resulting from production of other resources, and this is especially true in the timber-producing lands of Region One. For that reason, we in Region One need to give special attention to the field of watershed protection now and let water production or water regulation, as pertains to down-river influences, wait until a better job is assured on the lands being used primarily for the production of other resources.

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of points of conflict and areas for coordination between Watershed Management and the function of Range Management...... F.C.Curtiss

In the agenda for this meeting under Title II, Orientation section, our attention is called to an item of primary concern in the Region; that of the maintenance of existing conditions under the ever-increasing impact of all phases of multiple land use management. The measures required to offset the effect of these impacts, and the means for executing them on the ground, are the vital problems and challenge of watershed management. This brings us to the matter of identifying what the impacts are, where they conflict with watershed management and how they may be lessened or coordinated with it.

We need to know many things relative to the hydrological role of plants and the soil mantle, and the hydrological effects of other factors such as size, shape, topography and geology of a watershed, as well as climate. More research is badly needed as pointed out previously in this meeting, but much of this needed information is not going to be available to us for some time. It seems to me time is of the essence, and we cannot use lack of research as an excuse for delay. Administration is going to have to carry the ball. We will have to more effectively use what information we already have to maintain existing conditions of the watershed, and in some cases to improve them.

We know that if we overstock a range and let it continue for any length of time we will overutilize the forage, reduce its vigor, eliminate the desirable species, reduce the cover, expose the soil and in time break down the soil mantle. Research has given us this answer many times, and we know it from personal observation and longtime experience; yet in some instances we have let this condition continue for one reason or another. We also know that if we use a sheep driveway too hard it will cause similar effects, resulting in water concentration, gullying and erosion. Research has pointed out to us that moderate use results in better porosity of the soil, less surface runoff and little erosion; yet in some cases we continue to stock our ranges on the basis of the forage on the entire unit rather than on the usable or key areas, even after years of effort and observation have demonstrated that stock have not used the less accessible areas. There are a considerable number of faulty range management practices which have persisted over the years, a number of which are still continuing, that are in conflict with watershed protection. I have mentioned a couple above. To these can be added:

1. Worn out and permanent saltground locations.
2. Inadequate distribution.
3. Inadequate distribution of stock water.
4. Improperly located drift and division fences.
5. Excessive trailing by sheep.
6. Excessive sheep bedground use.

7. In some cases inadequate plans for management of livestock.
8. Lack of coordination with big game.
9. Use of range too early in spring.
10. Need for herders on many cattle ranges.
11. Optimism in increasing stocking on ranges because of a few good years.

To this list could undoubtedly be added many other unsatisfactory situations.

As defined previously in this meeting, the objective of watershed management is the production of water, usually as streamflow, in the amount and quality desired at a time when it is needed. One of the objectives of range management is to maintain the grazing capacity at the highest point attainable within the natural limitation imposed by fluctuating weather conditions. It seems to me these two objectives are pretty much in harmony from the standpoint of watershed protection. Perhaps if we reduced the forage cover we would obtain more water but would receive other ill effects. The quality of the water would be affected and the time when the water is needed would be affected.

By manipulating the various functions on the watershed, such as timber and forage, we will in all probability affect the watershed in one or all of these three ways; quantity of, quality of, or timing of flows. It, therefore, seems to me we have got to make up our minds first what we want. This would vary in different localities depending on water needs for farming, industry, domestic needs and other purposes. I am sure we all agree that the maintenance of the watershed site benefits for the production of high quality water is paramount to all other uses. However, there are certain limitations to this statement. None of us would advocate eliminating the other uses on the national forests to maintain the primeval conditions except in cases of municipal watersheds or extreme cases where very high quality water and flood prevention are absolutely necessary. Therefore, with the various conflicts involved, someone has got to make a decision on all watersheds as to what sacrifices, if any, can be tolerated in order to achieve the established objective. The partial loss of one use as against the gain in watershed, or vice versa, will have to be determined and agreed upon. We are managing resources which, as in the case of timber, take a hundred years or more to grow a crop; or forage resources which, if they deteriorate far enough, will take that long to restore. It is, therefore, necessary that we determine what the long range objective is. Once this decision is made, we can't reverse our course of action very easily. It is because of the long range nature of the crops we are dealing with that well thought out plans are so important.

As mentioned a number of times in this meeting, much more knowledge is needed to intelligently plan and manage for the future. Since, admittedly, we do not have all the answers to determine what is the best course to follow, we can play it close to our belt by trying to maintain the existing conditions on our ranges where we know they are satisfactory, and to restore to satisfactory condition those areas which we know are unsatisfactory.

We have been in business for 50 years. Why haven't we corrected all of the poor practices previously mentioned? Let me quote from one of the papers given at the Denver Watershed Management Conference:

> Assuming that we can graze some watersheds, and that our present objectives are fairly indicative of what should have been done to correlate the two activities--range and watershed management--then why hasn't the rig worked? First, there were many range areas in almost irreparable condition when we took over in 1905; second, we didn't have and still don't have for some types, the technical know-how to do the job; and third, we were unable in all cases to get the users and others to go along with us.

These three factors are not the only ones responsible for creating most of the areas of conflict and areas needing coordination between range and watershed management, but they are the principal ones.

Admittedly, these are formidable obstacles to eliminating many of the conflicts and lack of coordination between range and watershed management, but in my opinion none of them are sufficient reasons to prevent us from correcting many of the elementary things which our present knowledge and common sense dictates should be done.

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of points of conflict and areas for coordination between Watershed Management and Wildlife Management........... F.W.Johnson

Because of the great importance of watersheds to inland fisheries, this discussion will concern only watersheds in relation to protection of trout stream environments. Watershed management and its services to trout stream maintenance is logically divided into two phases, both of which involve coordination.

1. Broad environmental protection (Watershed)

Watersheds are as much a part of trout stream environments as the water in the streams. Abnormal floods do and can seriously reduce normal trout reproduction, food production and stream capacity. Examples of watershed behavior and stream runoff in Benton Creek - Priest River Experimental Forest and effects of abnormal floods in trout streams follow:

A. Benton Creek
(From paper presented by Al Stage, Priest River Exp. Sta., at the Northwest Scientific Ass'n. meeting, Spokane, Wn., Dec. 28,1955.)

Chart 1. Shows annual precipitation in relation to evaporation and transpiration rates which results in soil moisture deficiency and reduced runoff in summer and fall.

Chart 2. Shows annual precipitation in relation to stream flow. Very low period from July - October results in great reduction of trout habitat. This is the same bottleneck as game winter range. Better flows of water during the summer drought can be improved but little. Logging may bring about greater peaks of water flows in May, and cause serious damage to trout habitat.

Good water storage is required in winter months also. Underground water in winter is relatively warm. This supply of warmer water from underground sources is believed to help prevent development of anchor ice, or in preventing streams freezing solid. Stream water may be 30°F. Underground water may be 38°F.

B. Horokiwi Creek, N.Z.

Chart 3. Shows effect of abnormal floods on survival of natural and hatchery-reared fry to the yearling stage. Flood years - 1,500. Normal years - 12,000.

Chart 4. Shows quantitative results and effects of serious floods on fisheries and habitat compared to normal years. Briefly, this latter chart shows production ratios:

	Flood Years	Normal Years
Egg production	1	9
Trout numbers	5	15
Trout food	6	14
Trout size	4	5
Trout production - pounds	400	1500

2. Close in stream side protection

Protection of stream side vegetation is highly important for the following reasons:

A. Stream temperature requirements of trout.
B. Cover requirements of trout.
C. Stream bank stabilization.

Much of the materials eroded by spring floods in Region One comes from eroded stream banks. Stream channels when cut tend to spread water and to warm water. A good trout stream is a relatively narrow, deep, moving body of water, having a permanent channel.

3. Need and opportunities for coordination

A. Broad protection measures

(1) Effective fire control.
(2) Good upstream engineering.

(a) Roads.
(b) Timber sale operations.
(c) Dams. (One way in which to increase summer water yields.) Such systems of small dams have been in use in R-5 (California) for over 20 years.

B. Close in protection measures

(1) Proper road location and construction.
(2) Close herding on timber operations as to location of skid roads and proper attention following closing of timber sales. Cutting practices, especially on steep slopes and on areas of loose, easily eroded soils, should be planned well in advance if cutting is desirable at all. Leaving uncut or lightly cut strips of timber along stream edges.
(3) Keep all roads out of stream bottoms.
(4) Keep stream channel changes small. Avoid if at all possible.

C. Grazing

(1) Domestic livestock may destroy stream bank vegetation and break torn stream banks. Stream bottom fencing may be

required in places.

(2) Moose and elk have greatly reduced stream bank vegetation on many east side forest streams. Control of big game use required. Fencing not as practical as in livestock management, but some cases may require fencing of big game for the period required to obtain game reductions and restoration of stream edge vegetation.

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of points of conflict and areas for coordination between Watershed Management and Fire Control . . . . A. E. Spaulding

Effective fire control contributes materially to the objectives of good watershed management. Conversely, inadequate fire control in key areas can bring about floods, accelerate erosion, and may diminish the results of measures or practices instituted by other branches of resource management. Fire control is, therefore, an important and allied part of the broad field of watershed management.

It has long been considered that effective fire control on a broad, overall basis meant good watershed management. This may not always be the case when individual units are considered. A 10-acre burn in a critical watershed may be of much greater significance from a watershed-management standpoint than a thousand acre burn in a less critical area.

It has been recognized that our management plans should specify the allowable annual burn for the unit. The objective in an important municipal watershed could well be that we would permit no fire to burn over one quarter acre in size, while in another case, such as the high country in the Selway-Bitterroot Wilderness Area, it might be more economical and less critical from a watershed standpoint to permit a much larger burned area. These objectives are, of course, now taken into consideration in fire-control planning, but in the future will probably be given much more intensive consideration.

Major areas of conflict between fire control and watershed management are as follows:

Intensity of Protection.

Fire-control planners have recognized the need to more intensively protect one unit that is critically important from a water-management standpoint as compared to the more extensive protection needed for less critical areas. Due, however, to limitation on funds, the present over-all objective provides about the same degree of protection for all national forest areas. We need help from Research on a soil-vegetation survey to identify critical watershed areas.

To achieve the objectives of good watershed management, the fire-control organization should be geared to take care of the worst possible situation at least 8 times out of 10. We are now manned in Region 1 to take care of the worst situation in approximately 6 years out of 10. Serious fire situations above this level must be handled under emergency measures.

In this region, we have recently embarked upon a program of giving supplemental protection to slash areas, financed from slash-disposal funds in accordance with Manual instructions. We can make some additional progress along this line.

Fire-control planning needs to be stepped up, on a unit area basis, giving due consideration to watershed management requirements, and the plans implemented with the facilities needed to meet those requirements.

Suppression Costs and Techniques.

Fire suppression costs for large fires in critical watershed areas may be higher than costs on similar non-critical areas. Because of the values involved, suppression techniques may call for heavier than usual direct attack on the fire edge to hold burned area at a minimum. This procedure may be more costly than has usually been experienced.

Firelines and Access Roads to Fires.

A large portion of our firelines are now being built with bulldozers. These lines are usually located at points where the fire may be most easily controlled with such machinery. Access roads to fires may be of a steep and temporary nature that will induce erosion. In some cases, firelines constructed by other means may result in accelerated erosion.

We need to take steps to prevent such erosion. Reference is made to 3 FSM 305.19, which limits the use of FFF to the minimum amount of work absolutely necessary to open a useable way for transporting men and equipment to a going fire, and further, that this includes all work necessary to obliterate the way and provide needed erosion-control measures.

On April 28, 1954, we informed the forest supervisors that in fire-suppression work, following the completion of the initial dozer fire-lines, it is usually necessary to do some mop-up with dozers, construction of interior lines, and at times to have them standing by until the fire cools down.

While such dozers are in a pay status, they can usually do the incidental but planned erosion-control work deemed necessary. In addition to the above, men employed on mop-up and patrol work would have time at no extra cost to FFF to do the incidental but planned erosion-control work on firelines constructed by other methods. The Chief has authorized the use of FFF for this purpose.

To get this job done, it must be planned by the fire boss and instructions issued to the men responsible on the fireline so that we can get the job done.

Burned Areas of Critical Erodability.

Burned areas of critical erodability should be treated to hold the soil in place when feasible. We need to take pictures and explain the need to the Chief, to get special funds for this purpose.

Slash Disposal.

The debris created by logging is a serious fire-control problem in Region 1. Disposal of this material ranges from complete disposal by broadcast burning on clear-cut areas, or dozer-bunching and burning, down to no disposal whatsoever.

Care must be used in the methods of slash disposal employed to keep such work from contributing to accelerated erosion. Logging slash has been used successfully to prevent erosion and filter out silt in the runoff from new road construction and logging and skid trails.

Slash-disposal funds are not available to do erosion-control work. However, where lopping and scattering is a satisfactory slash treatment, costs to slash-disposal funds of a lopping-and-scattering procedure is justified.

If additional funds above that amount are needed to do the erosion-control work necessary on the area, additional funds should be provided under the erosion-control provisions of the G-T Act.

We need more information on soils where broadcast burning of slash is practiced to insure that our practices are not inducing excessive erosion or lowering excessively the productivity of the area.

WATERSHED MANAGEMENT IN ADMINISTRATION

Points of Conflict and Areas for Coordination
Between Watershed Management and Engineering . . . . R. W. Wilke

When speaking of watershed management in relation to engineering activities it is well to bear in mind that the function of engineering is that of service. Engineering activities are not an end in themselves, but a means to an end. It is axiomatic that economically at least, the end should justify the means. With the exception of wilderness areas, the efficiency of every type of resource development and forest management activity is dependent upon access to the area involved. Access may be gained by air, water, foot or horseback, but most commonly by road. The predominance of engineering activity is therefore concerned with roads.

This activity may be divided into five phases:

1. Transportation planning.
2. Location.
3. Design.
4. Construction.
5. Maintenance.

1. Since the cost of roads must be justified by the value of the resources to be developed it follows that the planning of a road system should be predicated on the location and value of these resources. To do an adequate job, the planner should have a resource inventory, a soils map and a land use plan. He should consider special problems and problem areas and plan to minimize road impacts on these areas. He can do this in a general way by avoiding problem areas, and by planning to service high value areas with roads located in areas of lower value. This is not always possible, of course, but insofar as it is, the transportation planner can minimize and by-pass many potentially serious watershed problems.

2. The location of a road might be described as the fitting of the road to the ground. The watershed management aspects involved in location are of considerable importance. Road location is easily the most misunderstood of all engineering activities. The mechanics of road location are so simple that even a novice can perform them. The technical considerations, however, are such that the novice rarely succeeds in doing an acceptable job. The brunt of his poor performance is borne by the designer, the builder, and the maintainer who all too often are blamed for the locator's mistakes. It is possible to design a poor road on a good location, but it is impossible to design a good road on a poor location. The competent locator must have a working knowledge of design, construction, and maintenance. He must know something about

soils and water and their relationship. He should know something about the resource activity for which the road is being developed. He should be aware of the economic limitations on construction funds, but he should also know the ultimate long range purpose of the road. The road should be located to a standard commensurate with its ultimate importance on the road system regardless of immediate economic limitations. If this ultimate standard must be compromised for economic reasons this should be done in design, not in location. Deviation from this principle is one of the primary causes of watershed management problems, besides it is usually poor long range economics. The access road program was set up to solve the economics of this problem, but we are still deviating in special cases due to emergency pressures and lack of professional personnel and time for adequate planning and location.

A good road location is one which results in the most economical road for the service it will be expected to furnish. A distinction should be made between economical and cheap. The road must fit the topography in such a way that maintenance costs will be held to a minimum. This is really the objective of watershed management, since road maintenance and watershed damage are very directly related. The three most flagrant violations of good watershed management practice in the past have been inadequate drainage facilities, the failure to limit grades in accordance with the soil characteristics and failure to keep away from stream channels wherever possible. A good road location keeps away from stream channels except for necessary crossings and where topography makes it an economic necessity. It has been said that there is a balance in the natural world which makes the right thing easy and the wrong thing chaotic. Nowhere is this more evident than where we attempt to inflict restrictions on the natural watercourse of a stream. As a nation we have paid billions of dollars for this foolishness, and we continue to pay out of all proportion to the economies we effect.

Channel straightening increases the sediment carrying capacity of the stream in proportion to the change in slope. At the downstream end of the channel change, the increased carrying capacity is lost, resulting in a deposition of sediment. The stream is forced to readjust to this change and the effects of the readjustment may extend for a considerable distance above and below the change and they may continue for a considerable period of time. Channel straightening also affects the timing of flood flows and may result in aggravating the flood peaks of a stream. The reverse, however, may also be true, indicating that channel changes are not necessarily always bad, but we need to understand what we are doing and take measures to counteract any bad effects of changes which we contemplate making.

3. A road disrupts the balance of a watershed by disturbing the soil surface and disrupting the normal drainage system. It is the designer's job to restore this balance as nearly as possible. He must keep soil disturbance to a minimum. He does this by adjusting the grade line to reduce necessary cut and fill and by carefully balancing the two he tries to eliminate waste or borrow. He maintains the drainage system as nearly as possible by providing culverts under fill sections.

Culverts should be laid on the original channel grade and should extend beyond the toe of the fill to avoid erosion. He must determine the proper size for culverts. If the pipe is too small it may result in loss of the fill. If the pipe is too large the added cost detracts from other features of the road. It is not economical to channel the water across the road at every existing water course. Some of them must be combined and channeled through a single culvert. This must be done with great care if erosion is to be avoided. Here the designer must have a knowledge of the soil and particularly any localized areas of high erodibility. By taking special precautions in critical localized areas the designer can eliminate or at least minimize many potentially serious watershed management problems. To do this, however, he must have all of the drainage and soil information that the locator can give him. After completion of design and prior to construction a plans-in-hand inspection should be made, giving special consideration to the adequacy of the designed drainage facilities, and necessary adjustments made in location and design to correct any bad features. Given a good location and adequate funds, the designer can usually design a road which will satisfy the criteria of good watershed management. More often than not, however, construction funds are limited and he must make modifications in design standards that may be detrimental to watershed management.

There are a number of design features in which the designer can cut costs and thereby cheapen the road. He can make it narrower, eliminate some turnouts, cut down on drainage facilities, reduce end haul by borrow and waste or steepen cut and fill slopes. Each of these is accompanied by a reduction in the ability of the road to serve its intended use, an increase in maintenance costs, an increase in damage to watershed values, or a combination of these facturs.

The designer can estimate with some degree of accuracy the increase in log-haul costs or road maintenance costs resulting from these cuts, but the damages to watershed values are more difficult to evaluate and, unless we exercise sound judgment along with economic analysis, the cheaper construction costs effected by the change in design will result in watershed damage far in excess of the saving in road cost.

4. Even with the most careful location and design, many problems arise from poor construction practices. Perhaps the most common offense during construction is the disturbance of much more of the ground surface outside of the road area than is necessary, and needless violation of stream channels by felling trees in them or running through them unnecessarily with bulldozers and other equipment. Supervision is especially important near the end of the working season to assure that partially completed jobs are left in satisfactory condition to withstand spring runoff. Any deviations from design specifications can, of course, lead to watershed management problems and our failure to construct or have the road constructed according to plan often is a very real source of trouble.

Problems often become apparent during construction which have not been anticipated but need to be dealt with. Highly erodible soils may be

encountered in limited areas requiring control measures which were not planned. Critical areas can be stabilized by riprap or paving in extreme cases. Exposed areas of soil should be seeded. Windrows of slash can be used to keep silt out of stream channels. The road builder should be alert to the causes of watershed damage and take measures to prevent it wherever possible.

5. Given a well located, designed, and constructed road, the dangers from faulty maintenance are reduced, but by no means eliminated. Some rather common faults of road maintenance are the undercutting of banks resulting in sloughing and erosion, the flattening of road crown by superficial blading resulting in improper surface drainage, and the piling up of a berm on the outer edge of the road, thereby channeling water when it was meant to be dispersed.

I have outlined briefly the various phases of road activity. What I have said applies to new permanent system roads. The principles involved apply as well to the improvement of the many miles of old substandard roads, many of which are contributing to watershed damage and must be dealt with eventually. The principles are equally applicable to temporary roads with certain modifications. On temporary roads the short term values have increased importance and the cheap road is often the most economical. Steeper gradients may be used because long term maintenance costs are not a factor and limited erosion damage can be controlled by water bars and revegetated when the road is abandoned. Temporary drainage structures will serve the short time needs and can be removed. Construction practices which permit disturbance of excessive soil and violate stream channels assume perhaps more importance because of the greater road mileage involved. Supervision and control become more difficult and need to be given greater emphasis to protect watershed values.

Besides the problems incident to the construction of new roads and maintenance of existing roads, we have a sizeable watershed management problem in the form of old abandoned roads. Lack of finances is a real problem in dealing with these roads. We are not handicapped, however, by emergency pressures and lack of planning time. We have much to learn about the methods and economics of treating abandoned roads and the best way to learn is by treating them and observing the effects of our work. The principles we learn here will be equally applicable in putting to bed temporary roads. I think research can be of great service in evaluating the effects of this work and recommending necessary or desirable modifications.

In addition to roads, we have about 27,000 miles of trails in Region One. Soil disturbance and potential watershed damage is not great. However, on steep slopes in erodible soil they are a potential source of erosion, and water bars or breaks in grade should be provided to prevent accumulations of water on long slopes.

Although roads are the dominant engineering function and consequently receive the most attention, there are a number of other engineering activities for which we have supervisory responsibility on forest land, some of which have serious watershed damage potential.

Power transmission line and oil and gas line construction presents a potential watershed hazard. These lines are generally run cross-country in a straight line pretty much regardless of steepness of slope. Consequently, travel along these routes during construction and maintenance can produce serious erosion problems and in many cases the removal of vegetation induces erosion. This clearing should be kept at the minimum required for safety and maintenance, and water bars should be required to prevent gullying on long or steep slopes. Critical areas should be seeded or planted when necessary.

Eastern Montana and the Dakotas are currently experiencing an oil boom of considerable magnitude. Numerous oil wells are being established on federal lands under Forest Service jurisdiction. This land is predominantly Land Utilization land which was acquired from the Soil Conservation Service several years ago. The watershed management aspects of these developments have serious potential. The drilling sites are located by state law in the center of alternate 40-acre tracts. More often than not, it seems, this location is on top of a hill requiring steep access roads and site leveling work involving considerable earth movement, or in drainageways complicating the drainage problems. We recently set up specifications to guide the oil company engineers in preventing watershed damage.

Reconnaissance of the area revealed that about 80 percent of the road mileage is on satisfactory grade, adequately surfaced and maintained, and drainage facilities are generally adequate to prevent excessive erosion. The other 20 percent is on excessive grade, predominantly approaches to sites located on top of hills where access at a reasonable grade is, in many cases, almost impossible because of the nature of the topography. Surfacing and maintenance is adequate, but lateral drainage facilities are not sufficient to prevent erosion in the road ditches. We feel that, since we have no investment in these roads and no responsibility for maintenance, the grade should be left to the discretion of the oil companies providing that adequate drainage facilities be installed to control erosion. As a guide to adequate drainage we recommend the following minimum culvert spacing on various grades:

Road Grade	Maximum Culvert Spacing
0 - 2%	1200 feet
3 - 7%	800 "
8 - 12%	400 "
13 - 16%	200 "
17 - 20%	100 "

In addition, we recommended that minimum pipe diameter be 18 inches, that culverts be laid on natural ground and that strictly temporary roads for one season use only need not have permanent type drainage structures but must be cross-ditched when abandoned. This cross-ditching should be done also where underground pipe lines are laid on steep slopes. Recommended maximum spacing for cross-ditches or water bars is as follows:

Percent Slope	Maximum Cross-Ditch Spacing
5 - 15	100 feet
15 - 25	75 "
Over 25	50 "

The drilling sites consist of leveled off areas about 100 to 200 feet square. Drainage ditches frequently are constructed so as to channel water off over bare fill slopes resulting in gullying and erosion. We recommended that this runoff water be discharged onto natural ground where there is enough protective cover to prevent gullying. One of the most serious violations of good watershed management practice which is taking place in these operations is the dumping of waste oil and water into sump pits which are commonly constructed by throwing up an earth dam in a drainage channel. These sumps are covered over with dirt when drilling is completed but in many cases they plug up entirely the natural drainage channel and runoff water must flow over this bare fill to get downhill. The inevitable consequence of this procedure seems obvious enough to be recognized even by an engineer. It is inconceivable that any thinking person could look at some of these sites and even entertain a hope that they will not eventually erode to the point where this stored oil waste will be carried downhill to contaminate grazing lands and streams below. Observations of this kind of work lead me to believe that it is this type of head-in-the-sand attitude toward some of our problems which is responsible for the bulk of our watershed damage. We recommended, of course, that these sumps be located away from natural drainage channels, that a pit be dug of sufficient size to permit filling in and restoring the natural surface contour.

Another engineering activity which has tremendous watershed damage potential is that pertaining to construction and maintenance of dams. For our purpose I think we should divide dams into three general categories. There are the large power, flood control and reclamation reservoirs built by the Corps of Engineers, Bureau of Reclamation, or public and private power companies. The aspects of these structures will be discussed later under the heading of special problems.

The second category is that of relatively small storage reservoirs located generally near the headwaters of mountain streams for the purpose of creating or increasing a water right. There are about 300 of these reservoirs in the region. They present a watershed damage potential which varies with the quantity of stored water and the steepness of topography and nature of improvements downstream. In the event of failure of the dam and a sudden release of stored water the downstream effects are usually catastrophic. There are a number of scattered cases in the region where reservoirs have failed. The usual result is the complete removal of all soil and vegetation in a swath down the mountain varying in width up to several hundred feet, and the deposition of this soil in the drainage ditches and stream channels below. We have been fortunate that these failures have never resulted in loss of life but the potential exists in all cases and in many there is a potential property damage of many thousands of dollars. A dam failure can usually be attributed to one of two things: either the structure was not properly designed, constructed, and maintained to withstand the

normal runoff, or it was subjected to a runoff rate in excess of that for which it was designed. More often, perhaps it is a combination of the two. Since the rate of runoff is not within our control, we can only see that the structures are adequately designed and constructed, and maintained in a satisfactory condition. Presently we require an applicant to submit an engineering design before permitting construction of a reservoir on national forest land. Designs are made by the SCS, FHA, State Water Board, or private engineer. Construction is supervised by the designing agency and FHA and the State Water Board follow up with maintenance inspections. The SCS leaves inspection generally to the Forest Service. Design standards of the various agencies are reasonably uniform and generally adequate. There is room for some improvement. I think the only important defect in our present designs is that very often the dam is designed to store the desired quantity of water with little consideration given to the total runoff from the contributing area. This has two undesirable consequences. One is that the site is not utilized to its full potential, the other is that the emergency spillway becomes a route for all excess volume beyond the storage capacity, resulting in unnecessary damage to the spillway and consequent maintenance costs.

Perhaps this statement requires some clarification. Basically, a dam consists of three functional parts: the fill, the outlet works, and the emergency spillway. The fill forms a barrier to the flow of water. It must have at least a core of impervious material to prevent the flow of water through, under, or around it. Its upstream and downstream slopes must be flat enough to provide stability against the force of the ponded water and the erosive action of the elements. Like a chain, it is only as strong as its weakest point. The outlet structure consists of an opening, usually in the form of a corrugated metal pipe to permit flow of water through the fill, and a gate to control the rate of flow. The pipe should be long enough to discharge without damage to the toe of the fill. Often it is necessary to construct a concrete outlet structure to dissipate the energy of the water without erosion. The inlet should be protected against damage from floating debris and the gate control should be similarly protected. The emergency spillway as the name implies is a safety valve to prevent overtopping of the fill. It consists of a low section of fill over which water can flow without damaging the fill. It should have sufficient capacity to prevent water from backing up and overtopping the fill. From a safety standpoint it is the most important part of the dam. If the dam is properly designed all of the runoff water will be stored below the spillway crest elevation. Water will flow over the spillway only in the event of an unusual runoff. Since an unusual runoff does not occur every year, the dam is not properly designed if the spillway carries water annually. These remarks apply to the type of earthfill dams we are commonly building today. Before the development of modern earth moving machinery many dams were built of rock masonry. These dams generally had very small spillways, if any, and they exist today because they can stand overtopping without damage to the masonry fill. Most of them have leaks and the outlet works are often dilapidated to the point of not functioning. The high cost of hand labor today precludes this type of construction. When this type of structure deteriorates to the point where failure appears imminent, it is generally most economical to replace them with an earthfill dam. The ideal time to do this is the summer before they wash out.

I think the chief criticism of our activities in regard to these irrigation dams in the past has been our failure to prescribe and vigorously enforce the performance of necessary maintenance work. Our files contain numerous reports of engineering inspections of these structures recommending needed maintenance work which, after 10 or 15 years in some cases, has not been performed. The fact that the structure still stands is in most cases not a reflection on the engineer's recommendations. A structure may get by for years merely because average or below average runoff has not subjected it to undue strain. Several have failed, and the damage done probably exceeds the total cost of the recommended repairs on all of them. We have adopted a policy of more enthusiastic enforcement of maintenance in these cases. Some progress has already been made and more will be forthcoming.

Another aspect of watershed management is the access roads which are built to these dam sites for the purpose of getting construction equipment in and to provide access to operate the headgates. To the permittee, economy of construction is the prime requisite of these roads. We must insist, however, that they be built with consideration for watershed values. The cost of the access road must be considered a part of the project cost to determine the economic feasibility of a project.

The third category of dams is that of stockponds. These are generally small earthfill dams to provide stockwater on grazing lands. They are built in relatively flat, sparsely populated, grazing country and their watershed damage potential is not great. They normally have no outlet structure and the emergency spillway is the crucial feature of construction and maintenance. Adherence to the few basic principles of design and construction would be sufficient to eliminate any watershed damage hazards from this source.

In summary, engineering activities are concerned with the design, construction and maintenance of roads, power transmission lines, oil and gas pipe lines, oil wells, and dams. In general, we know enough to prescribe adequate standards. Conflicts between engineering work and watershed management result from lack of performance in accordance with standards. In the case of road activity lack of performance is caused not only by failure to perform to standards but by a compromise in standards induced by financial limitations. In a sense, the conflict is between watershed management and the resource development for which the road is being built. The resource manager, quite understandably, wants to cut costs wherever possible. He wants to spread available funds so as to get the greatest possible mileage of road for the money. Often in emergencies he wants roads built quickly. He needs a lot of roads and often he needs them quickly to do a good job of resource management. But cost cutting (through lowering of standards) and speed usually exact a penalty in the form of watershed damage, high maintenance costs, or a poorly developed road system. They can also affect the profit derived from the resource involved. A road system should be considered a production facility which permits maximum output at minimum operating cost--hence maximum profit. When considering the economics of roads we should keep in mind two basic facts:

(1) That economy is an inherent measure of good engineering performance. Anyone can build an adequate facility, given enough

money. The primary purpose of engineering design and planning is to determine the most economical design which will adequately serve the intended purpose--over the useful lifetime of the facility.

(2) Building a facility to a low standard and ultimately improving it to a higher standard invariably costs more than building to the higher standard initially. Most of the differences in opinion regarding road standards are actually a difference in opinion as to whether and to what extent we should sacrifice present profits in return for long term returns.

We have learned that there is an optimum road standard which will yield the highest profit from timber harvest. We have learned to evaluate road costs versus timber haul costs to get the greatest return for our investment. It would seem that returns in the form of watershed protection should be subject to the same type of analysis. Certainly there must be an optimum road standard which will yield the greatest return on our investment in the form of watershed protection, as well as in log haul costs, and the two should be evaluated together. It is equally certain that this optimum is not the same for all watersheds. We must differentiate in our method of operation between a watershed which empties into the Missouri River and one which empties into a municipal water system. Good watershed management does not mean the same thing in all watersheds. Watersheds vary in resistance to erosion; they vary in quantity and quality of water supply; they vary in natural resources. The amount of money we can justifiably spend to protect them, therefore, varies also. It will probably be some time before we develop a satisfactory technique for economic analysis of watershed damage. In the meantime, we must do the best we can to weigh all the factors involved from an unbiased viewpoint. We must refrain from using our lack of knowledge as an argument or excuse for doing nothing, when actually we know enough to do a creditable job if we will apply our present knowledge as best we know how, and, finally, we must stop looking to the other fellow to do the job of watershed management and realize that it is as much our responsibility as his.

We have separated administratively a job which must be integrated on the ground if it is to be effective.

Aldo Leopold once said that all men can be classified into four groups: the big game hunters, the bird hunters, the duck hunters, and the nonhunters. When they are in the field the big game hunter watches for big game, he doesn't see anything else, the bird hunter watches the dog, the duck hunter watches the sky, and the nonhunter doesn't watch anything. I think we might draw a parody on this description to apply to Forest Service employees. It is certainly a fact that we see what we are looking for. We don't see watershed damage unless we look for it and if we don't see it, of course, we don't do anything about it. Watershed management is not the job of the watershed manager, we don't have one. Under our present administrative setup, watershed management is an inherent part of the job of every resource manager from the ranger on up to the Chief.

Collection of runoff data by velocity head rod measurement

There is a need for runoff data, particularly maximum peak data for culvert design, at points upstream from U.S.G.S. streamflow gages. It is proposed to undertake the collection of this type of data by employing the velocity head rod to measure streamflow. Measurements and pertinent data will be collected by District personnel and forwarded to the regional office for tabulation and analysis. Runoff maps will eventually be developed for each forest. Velocity head rods will be procured and distributed with instructions for their use and recording of data. We hope to begin collecting runoff data during the peak runoff period this spring.

The regional office is purchasing a turbidimeter, an instrument for analyzing the turbidity of water samples. The plan is to obtain turbidity samples along with discharge measurements on critical streams to provide an indication of the effects of future developments in the watershed upon stream turbidity. We plan to get out more detailed information in this respect along with instructions for discharge measurement.

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of points of conflict and areas for coordination between Watershed Management and State and Private Forestry. . E. H. Juntunen

Three-fourths of the nation's commercial forest land is privately owned. About 350 million acres.

When we speak of large and medium size forest owners, we refer to approximately 3500 who manage and control their lands to promote good watershed management. The other $4\frac{1}{2}$ million owners of small forest tracts in the aggregate control 60 percent of the commercial timberland.

These statistics indicate the scope of the job and a basis for considering how we might improve watershed conditions on these lands.

It should also be remembered that in most instances the small owner of forest lands is primarily concerned with "on-site" benefits, while many of the values, if not most, of watershed management are "off-site."

The over-all objective of the Forest Service is to promote sound management and wise use of all forest lands. To exercise the leadership and provide the cooperation necessary so that other agencies and groups will do the parts for which they are responsible.

Webster defines "cooperation" - to act or operate jointly with another, implies joint action or operation on a partnership basis. Does not have to be equal - 50/50 basis.

Leadership - office, position, or dignity of a leader; also, ability to lead. In our programs, the last item (ability to lead) comes closest to defining our operations under federal-state cooperative programs. It is in many ways a form of friendly, expert advice. Our most effective devices for aiding the states are persuasive devices. Program objectives and program development should receive the emphasis rather than credit for the program.

In the early days of the forestry movement, the Forest Service sent its men to examine private timber tracts and give advice on management. The Chief's annual report of 1910 initiated a shift of responsibility for management examinations from Forest Service employees to the states and to private consulting foresters. It was recognized from the first that the best way to promote good management of privately-owned forest lands was through the state foresters and consulting foresters in the individual states.

For this discussion, let us consider watershed management in four separate phases:

1. Recognition of existing conditions.

2. Restoration by engineering or vegetation.

3. Protection from fire or other damaging agencies.

4. Improvement phase to increase yield of water.

The Federal Government recognized the need to assist states and private forest land owners in the protection from fire of forested and watershed areas in the headwaters of navigable streams by enacting the Weeks Law in 1911. This program of Federal-State cooperation started under this law was further strengthened and broadened under Section 2 of the Clarke-McNary Law of 1924. The Clarke-McNary Law not only includes protection of watersheds of navigable streams, but also to any timbered or forest-producing lands or watersheds from which water is secured for domestic use or irrigation.

The cooperative forest fire control program with the States and private woodland owners is of long standing, generally understood and accepted.

The significance of program acceptance is illustrated by the fact that 44 states and Hawaii are now actively participating in the program. It has been effective in reducing fire losses. The average area burned (1926-30) was 41-1/2 million acres, while the annual loss for 1950-1954 was 11.8 million acres.

The watershed programs under Public Law 566, passed in 1954, and the Pilot Watershed Program of 1953 now cover relatively small areas (a watershed) maximum of 250 M acres per project, which in most cases, are now included under the Clarke-McNary 2 fire program.

The Clarke-McNary Section 2 program provides for a basic level of protection. The watershed programs ordinarily call for a higher degree of protection. Their small size and scattered location present a problem in planning, in coordination and integration between these programs and the statewide cooperative fire programs. Where intensified forest fire protection above that now provided is required under the watershed programs, watershed sponsors will have to pay the cost of additional protection required.

Although administration of the watershed program and fire programs differ and some problems will have to be solved, to avoid patchwork protection standards, the fire protection phase of watershed programs should be integrated into the existing, firmly established, nationwide Federal-State cooperative fire program.

Section 4 - Clarke-McNary. This section provides for Federal-State cooperative program for production and distribution of forest planting stock for windbreaks, shelterbelts and farm woodlands. It ties into the watershed program where tree planting is one of the watershed measures necessary on the project. In discussing watershed management we must assume that to the greatest extent possible we will be working through the state foresters in coordinating watershed management activities on state and private lands.

Section 5 provides, through land grant colleges, for forestry educational assistance to farmers.

Cooperative Forest Management. The Cooperative Farm Forestry Act of 1937 authorized the Secretary to cooperate with the states in a program, among others, of conserving water resources. This act was

replaced by the Cooperative Forest Management Act of 1950. The act provides for the development of Federal-State cooperative programs to secure better forest practices by providing on-the-ground technical advice and assistance in woodland management and processing of wood to individual forest owners and operators.

Where watershed projects fall within CFM projects, service foresters provide technical services to the woodland owners in the watershed. The same problem arises here with the Cooperative Forest Management program as with fire. If intensified timber management service is required in the watershed area of 15,000 to 50,000 acres, the State Forester cannot intensify his service by assigning a man to that watershed when over the rest of the state one forester is servicing several counties. The additional work-load in a watershed may be sufficient to justify the employment of a full time forester. Should watershed sponsors pay for the extra services needed?

The laws briefly covered - Clarke-McNary, Section 2 (fire), Section 4 - production and distribution of forest trees, Section 5 - extension foresters, and CFM law, form the solid foundation of the broad national interest in better forestry and watershed management on state and privately owned forest land. They were clearly designed to encourage the individual states to develop programs for accomplishment of these jobs.

They also clearly indicate that even though the broad public interest warrants continuing federal financial assistance, the administration of these three basic programs for private lands is the State's job. The Forest Service, strongly backed by the Association of State Foresters' has steadfastly held to this policy. Our insistence that the private land forestry and watershed management problems incident to the administration of other Federal-assistance programs such as ACP, Pilot Watershed Program, and Public Law 566, 83rd Congress, be handled by the states so as to integrate and correlate them with the basic forestry and watershed programs is evidence of sound backing of the above policy. It is important that we maintain this policy to facilitate accomplishment of the long term objectives.

Other programs that supplement the cooperative programs covered are:

The Forest Pest Control Act of 1947 - authorized cooperation with any person, organization, public agency or state to investigate, plan and carry out necessary measures to prevent and control outbreaks of destructive diseases and insects for the purpose, among others, of conserving forest cover on watersheds.

What are the relationships of insect and disease control work to the broad field of watershed management? Research is needed to determine if such attacks warrant an intensification of control program on watersheds. Basic facts are needed to "sell" the program to owners.

Watershed Projects under Public Law 566 are to be covered later by Lobenstein. However, projects with forestry measures on private lands under this program tie into existing Federal-State cooperative programs. They supplement cooperative programs which the state is handling and the policy is to look to the state for technical planning and guidance on the private forest lands. The on-the-ground job is that of the State Forester.

ACP. This program also supplements the states CFM program by providing federal financial assistance to private woodland owners for carrying out forestry measures on their woodlands.

A-7 - Planting.

B-10 - T.S.I. plus erosion control on skid roads.

Also provides for assistance for practices carried out on federally owned lands under certain conditions. If private owner has the federal land under a use permit and the practice benefits adjoining privately owned lands of the person carrying out the practices.

Title 9 - USDA Regulations - 1954. Gives the Forest Service responsibility for "leadership" in all Department forestry activities and for carrying out the Department's cooperative forest programs.

Delegation of authority to the SCS for determination as to what lands are to be in forest or woodlands could conceivably cause difficulty in each of the three basic cooperative programs, and also in the allied ACP and small watershed programs.

Item 400 C.2 - Assigns to SCS responsibility for flood prevention plans, installations, etc., except certain responsibilities assigned to the Forest Service. Herein lies some of the difficulty if the central office or field men are unsympathetic to forestry phases.

Other Memorandum. No. 1278 Secretary issued in 1951. McArdle-Williams memorandum of September, 1954 defining the responsibilities of the Forest Service and SCS in the Department's flood prevention, conservation and watershed programs.

Tripartite Agreement. Limits the Forest Service to forest protection and complex forest management problems. Secretary's memorandum #1325 of April, 1953, withdrew Forest Service authority for flood control surveys and to prosecute measures for runoff and waterflow retardation and soil erosion prevention within its zone of responsibility, which had been set up under the 1936 Flood Control Act.

Attempts are being made at the Washington level to iron out difficulties and duplications, and provide directives so worded that the issues will be clear.

In the meantime, the field should be alert to requests for assistance or participation in preparation of simplified forestry handbooks, soil site charts, management sticks, formulas such as D-6, and the like. Also, signing any such compilation, which may or may not give away our responsibilities for forestry matters. Would be embarrassing to the Chief if field officers abrogate Forest Service responsibilities.

Quasi-Public and Group Organizations. Quasi-public organizations have become important and influential. Their power and influence are determined by the purpose for which they are organized, their total membership, and their leadership.

There are many hundred such organizations in the United States. As pointed out by Regional Forester Hanson with his "deck of cards" illustration.

Some are national, S. C. districts, some organized on a state basis, such as Fish & Game associations, others local such as municipal water districts. As the population increases, each will clamor for their respective share of water. The demand and interest in watershed programs will continue.

We should know and work with the organizations in our area. A local program or project that reaches state or national attention draws the cooperation of other closely allied organizations.

"Know Your Watershed."

Summary

Need help of all Forest Service employees in the Region, assistance and encouragement of other agencies to join in making these programs productive tools in improvement of watershed areas.

Identification of points of conflict and areas for coordination between Watershed Management and Recreation and Lands . . R. U. Harmon

Recreation

Concentration of people has a tendence to compact the soil. Compaction of the soil generally results in a more rapid runoff of water and on more heavily concentrated camp and picnic areas there is an appreciable contribution to the flood control problems as a result of this activity. The most pressing impact, however, is probably the impact upon the quality of the water. Large concentrations of people create sanitary problems. If ample funds are available for the construction of facilities to take care of people, the sanitary problem can pretty well be taken care of. However, this is not the case and has not been for a number of years, with the result that recreation use on the national forest is contributing a major portion of the pollution of our mountain streams. Fishermen and hunters, of course, do not use our developed areas and they contribute to the pollution problem materially.

Uses

Many uses are authorized on the national forest. These include pipelines, transmission lines, logging roads, roads of other descriptions, agricultural permits, and others of various types. All such uses invariably create a disturbance of the soil mantle. Such disturbances generally result in erosion problems. Such erosion may be short-lived, but nevertheless, it exists for temporary periods of time. Good planning of the location of such installations and extra care in their construction can, of course, eliminate many of the hazards.

Mining

The mining law permits the prospecting and development of the mineral resources on the national forest that came to us from the public domain. There is no restriction on the method of prospecting or in the development of the mineral resources included in the federal laws. Some state laws require certain protective measures. The mining situation, however, is not adequately covered by laws or regulations to permit imposing even the simplest restrictions that could contribute to better watershed management.

General

Perhaps the greatest impact of recreation and the users of the national forest comes from the public reaction from such groups to other activities carried on in the national forest. In other words, if we make mistakes in our road construction program, in our logging, in our tractor skidding, or other activities that result in disturbing the soil mantle, resulting in contributions to the destruction of quality and quantity of water, the reactions to such programs may be far-

reaching in extent. These groups have a tendency to create a great deal of distrubance and public opinion reacts favorably to many of their proposals. If we do not operate in a sound manner and adequately protect our watersheds, it is very possible that public opinion may curtail or eliminate some of the activities that we consider as essential for the sound utilization of the resources on the national forest.

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of points of conflict and areas for coordination between Watershed Management and its impact upon special programs

Flash floods . . . . Z. G. Smith

During lateMay and early June of 1953, the Great Falls general area suffered one of its most serious floods in history. The situation developed with a low pressure area, which was about 150 miles in diameter. Heavy rainfall began on May 24 and extended through June 3. The Highwood Mountains were the approximate center of the low pressure area and received the heaviest rainfall. Precipitation was progressively lighter to the outside perimeter of this low pressure area. Official Weather Bureau records are as follows: 18.79 inches at Shonkin, which is near the center of the low pressure area; 9.9 inches at Great Falls, some 25 miles out from the center of the low pressure area; 7.72 inches at Sun River; 7.03 inches at Augusta; and 5.4 inches at Gibson Dam, some 75 miles distant from the center of the low pressure area and about the edge of the storm.

Snow pack in the mountains was below normal and since it remained quite cool during the period of the storm, it appeared that snow melt over much of the watershed at higher elevations was retarded and that it contributed only a small extent to high waters in the lower elevations. Exceptions to this involved the Highwood Mountains and the east slope of the Little Belt Mountains which were within the heavy rainfall area. All of the snow pack went off of these particular areas during the period of the storm.

Rainfall generally was not of the torrential or cloudburst type, although high intensities did occur locally. The highest intensity recorded officially was at Great Falls where precipitation fell at the rate of .84 inches per hour for a short period. At Shonkin $6\frac{1}{2}$ inches of rain fell in a 24-hour period. One small area at the head of a drainage in the Highwood Mountains washed badly and indicates that near cloudburst conditions may have occurred. The most of the run-off water, especially from the high forested land, resulted from rapid return flow from saturated soils. This came as seepage at a steady rate and was augmented at times, especially in the foothills and plains areas, by more rapid surface runoff following periods of heavy rainfall. As a result, all feeder streams were running at least bankfull and the natural scheduling of runoff, which ordinarily protects the secondary streams from flooding by snow melt or local cloudburst type storms, was ineffective.

Great damage was done to homes, industrial plants, roads, bridges, and other structures. Damage of this type was roughly estimated at about $5\frac{1}{2}$ million dollars. Serious damage not included in these figures was also done to the stream channels and to the soil. While there was little evidence of surface runoff and sheet erosion on the

higher forested lands, moderate severe sheet and shoestring gully erosion was common on bare crop land and on heavily grazed range lands at lower elevations. Channel scarring, bank cutting and deposition of debris of all kinds constituted the greatest damage.

Debris was a major factor causing damage in headwater areas. Beaver dams, logging slash, fire and diseased killed trees, mining waste and road fills, abandonded mill ponds, inadequate culverts and bridges, all worked together in restricting the orderly flow of an unusually large amount of water.

Damage resulted from a series of chain reactions. Debris in small streams temporarily built up a head of water. The obstruction then gave way and the rush of water picked up additional gravel and debris. A bridge or culvert downstream was soon clogged and a larger head developed. A series of breaks and crests progressed, each worse than the one before. As these supplemented one another in the converging water courses, large structures were swept away and excessive channel washing occurred.

When we were able to get out into the forest, we found the following: 40 miles of road washed out or seriously damaged; 34 bridges washed away which included 100 ft. steel beam bridge across Belt Creek below Neihart; 100 miles of trails washed out or damaged to a serious extent; 7 miles of telephone lines requiring reconstruction and 2½ miles of telephone lines requiring extraordinary maintenance; 3 camp and picnic areas seriously damaged. One of these areas was so severely channeled that it had to be abandoned. The water and sewage system at the Belt Creek Ranger Station destroyed.

A survey of the damages and a cost estimate of a rehabilitation program were made as rapidly as possible. Although there were many offers from outside people to help the Forest Service secure special appropriations for restoration work, it was determined that this would not be a desir able approach. It has become accepted procedure for the Forest Service to absorb such disasters of this scope from their regularly appropriated funds. Accordingly, it was decided to allot the Lewis and Clark extra funds for restoration work and accomplish the entire program over a period of two to three years. I am glad to say that all of the road and trail work has been accomplished, with the exception of one recon struction job in Logging Creek. This is now under contract and is about one fourth complete. Completion will be realized before June 30 of this year.

While we were absorbed with our own troubles on the national forest, the cities, towns, counties, state, individuals were busy with their own reconstruction and restoration programs. Towns and landowners located along the stream bottoms at the lower elevations suffered tremendous damage. Entire fields were washed away and stream channels had changed and meandered all over the drainage bottoms. Most of the area was proclaimed to be "disaster area" by the President and became eligible for Federal assistance from the Corps of Engineers and from the Soil Conservation Service. Meetings were held throughout the area by those two agencies in order to explain to the people what financial aid could be

secured. From these meetings a coordinated program was developed. The Corps of Engineers would take on channel restoration work within and adjacent to the small towns. The SCS would plan and finance channel cleanup and channel restoration work outside of the towns and on privately owned lands. I was asked to participate in most of these meetings and it became obvious that the Forest Service should participate in this overall program, if it were to have more than temporary benefits. This situation revolved around the fact that the Forest Service is administering the upper portions of the watershed. Many miles of stream channel had been washed out. New channels had been cut. Debris had been gathered up by the high waters and deposited in huge piles. Thousands and thousands of trees had been uprooted and left here and there and all of this was subject to being picked up by high waters the next spring and carried downstream, with the possibility of destroying all the work that the SCS and Corps of Engineers were doing. We were really on the spot and for a long time it did not appear that there was any possible way of our securing funds to accomplish the necessary channel restoration and the channel cleanup work. However, it was determined that the Soil Conservation Service had a sizeable appropriation available to them under the Flood Control Act of 1952-53, Public Law 371. These funds could be used on national forest lands, inasmuch as they would affect people and programs downstream. The SCS was unwilling, primarily because of limited personnel, to come on the national forest and undertake the rehabilitation work. Neither were we anxious to have them come in and do this work for us. The result was that we reached an agreement with the SCS where they would provide us with $33,000 and we would perform this rehabilitation work, subject to their approval of the extent of the work and the type of work that would be done. We immediately got a survey underway, mapped the miles of stream channel that would have to be treated and presented it to the SCS. They sent out an engineer who spot checked this and gave approval to the program as presented. We then proceeded under the terms of the agreement to send out invitations for bids on this work and got it underway in November of 1953. The job involved the treatment of 55½ miles of stream channel and was completed on December 22.

The impact of that flood on the organization of the Lewis & Clark was great. We think back on much of that period as a nightmare. The impact on the entire region was great because funds had to be diverted from other forests in order to perform the rehabilitation work.

We got much satisfaction out of the fact that our watershed did not fall apart. It functioned as a huge sponge, which eventually became completely saturated and then oozed out water everywhere. As this runoff accumulated in streams, the volume became so great that the channels could not carry it and it was here that the damage occurred. There are, however, certain things that stand out and point to better practices in these headwater areas. Most forest managers and engineers already know of these practices, but I think that they are worth setting out for emphasis:

1. Keep debris out of channels. Logging slash and the natural windfall of dead trees constitute a real threat to stram stability during high water periods. Debris that has become a part of the stabilized channel should not be removed, however.

2. Avoid infringement of roads on streams. Straightening a channel along a forest road or highway by rerouting the stream and constructing fills is asking for trouble. This practice usually speeds up the flow in a channel that already has a steep gradient. Bank cutting and degrading takes place in a straight reach and the material is deposited at the foot of the run where a braided channel and further cutting and meandering develops.

3. Culverts must be large enough to accommodate peak flows. Damage to relatively new highways occurred in the Great Falls area because of inadequate culverts.

4. Channels under bridges must be adequate and bridge piers must be so constructed and placed as to minimuze plugging by debris in high water periods.

5. Road fills, especially at stream crossings, must be adequately stabilized to prevent washing.

6. The best in land use practices, covering fire protection, livestock grazing, and intelligent logging methods, all help to prevent rapid runoff, maintain high infiltration rates, and generally minimize the effects of critical high water periods.

Forest managers should be familiar with practices and conditions that will form potential chain reactions along headwater streams and to avoid them or take corrective action while it is not too late to remedy the situation.

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of points of conflict and areas for coordination between Watershed Management and its impact on special programs

Forest insects...D.O. Scott

From the papers presented at this meeting it is evident that there have been extensive forest influence studies in various parts of the country, since the passage of the McSweeney - McNary Forest Research of October 1928. However, the relationship of forest insect control work to the broad field of watershed management apparently has not been considered in these studies.

It appears now that endemic insect losses may actually improve watersheds, while epidemic insect conditions have caused serious watershed management problems. As mentioned yesterday most of the even-age stands of merchantable timber in Region One are mature or decadent. This class of sawtimber presents ideal conditions for insect epidemics, as tree killing bark beetles and defoliators seem to prefer trees of low vigor. Under the present rate of cutting it will take at least 30 to 40 years to remove this susceptible timber. Therefore, we will have to consider forest insects along with other watershed problems for many years.

During the current spruce beetle epidemic, for example, it was necessary to initiate a logging-for-control program in some of the highest water yielding forest areas of Region One. In many of these spruce areas, the severity of the infestation was greatest in the stream bottoms. This necessitated special road building requirements, and special felling and skidding practices along streams to prevent watershed damage. There have been two methods of marking used on forests in the beetle control program. Some forests have spotted the infested trees while other forests have clearcut spot infestations. On a few forest patch-clearcutting was necessary, because of the economics of removing small infested volumes.

Logging-for-control, chemical spraying of standing infested trees and the chemical treatment of felled trap trees presented problems on two watersheds within the national forest boundaries on several forests.

Some administrative mistakes were made and often magnified many times. But, in general, under the emergency that existed, most forests did a real job in removing infested timber economically with a minimum of watershed disturbance.

From our experiences with the spruce beetle epidemic we know that early detection of abnormal insect conditions is a requisite for good watershed management. Early detection of "hot spot" infestations which

are potentially dangerous can only be accomplished by alert field men well trained to recognize the seriousness of these situations.

Although the Forest Insect Laboratory is responsible for detection surveys, their organization is not large enough to cover the enormous forested areas which should be examined annually. Thus it is imperative that all field going men watch for and report abnormal insect losses currently. Are our present instructions for this job adequate? How can this job fit into our present work plans? How can we train men at the forest level so they will not overlook dangerous insect conditions? Should we have trained observers in fire patrol planes?

The next step beyond reporting is the question of responsibility for receiving and coordinating the reports. Is our present system workable?

The present spruce budworm epidemic is a serious threat to our Douglas-fir watersheds. Since 1948 the infestation has been extending its boundary annually, until now it covers about 2-3/4 million acres.

Last year an action program was set up to control this defoliator. About 133,000 acres on the Gardiner Unit, and 169,000 acres on the Bitterroot Unit were aerial sprayed in 1955. This year 650,00 acres have been proposed for a control program. Control on the remaining acreage depends upon cooperative financing. This is a limiting factor where Federal, state, and private lands are intermingled.

From past aerial spray programs it has been found that more research is needed to establish the relationship between aquatic insect mortality and DDT spraying over western streams.

Also, we need better guidelines and technical know-how in determining the exterior boundaries of budworm infestation. For example, last year we started out expecting to spray 58,000 acres on the Gardiner Unit, and ended the project by spraying about 133,000 acres.

Apparently, endemic insect infestations do not seriously effect a watershed, but they may improve it. Epidemic infestations may increase water yield, but they are detrimental to good watershed management. To prevent serious insect epidemics we must detect abnormal conditions and control the "hot spot" infestation.

Identification of points of conflict and areas for coordination between Watershed Management and its impact on special programs

Big dam projects. . . . . .George F. Christensen

The increasing population of the western United States, as well as the westward progress of industrialization, has created an increasing public demand for water, power, irrigation and flood control. The construction of large dams for any of these purposes presents many problems in the administration and use of the public lands affected by the reservoirs created.

As the populations have grown and standards of living have increased, the demands for and values of all the resources on many of the national forests also have grown and increased, and in even greater proportion, for quite a few of these forests represent areas and contain resources which are just coming into full focus. These demands are now requiring greater and more rapid development and more intensive management for greater production. There are other national forests in which such intensified demand will be only a matter of time.

Total resource development on the national forests requires, in addition to development of water reservoir resources, full regard for all other basic resources. Provision for less than such full regard of all other resources is short-sighted national policy.

To attain throughout all phases of planning, proper, timely and adequate regard for all national forest resources, it is essential that responsibility be placed legislatively on the Secretary of Agriculture and the necessary funds be provided to him. These funds should be used for analysis, evaluation, planning, report and recommendations as to the place of national forest resources in relation to the proposed projects.

Experience also shows that reservoirs on national forest lands create immediate problems and demands, for which provision must be made at the time of project construction if avoidable losses in resource use and facilities are to be minimized, if uses created are to be properly managed, and if resource values are to be properly protected. Authorizations and funds for federal water development projects should include provisions for these purposes, both developmental and administrative.

In different areas, regions and forests, the problems will vary. It appears that one of the serious impacts of large dams and reservoirs on the administration of national forest lands is the disruption of established transportation facilities. Ordinarily,

the products of the forest flow down a road system having the same general pattern as the drainage system; that is, the tributary roads are located in the smaller side drainages and connect to the main road located along the principal drainage. Most of these roads are located on the more level valley bottoms or gentle lower slopes and may be inundated by the backwaters of the dam. Road construction is more economical on these lower elevations than along the steeper mid-slopes. Prior to the construction of dams, usually it is relatively inexpensive to construct bridges across the main rivers, to facilitate administration, and to harvest products of the forest. The backwaters of dams become barriers that split or separate the drainage. Where this occurs, it may be necessary to have main roads on both sides of the reservoir. Before dam construction, roads can be constructed up the drainage as the area develops and needs become apparent, replacing the first system, usually trails or low-class protection roads. Heretofore, other agencies concerned with dam project plans have seldom properly considered these features in the planning stages. All forest products cannot be economically transshipped to processing plants. Ice on reservoirs at higher elevations and along the northern portions of the United States prohibits transportation by water during the winter months.

Fluctuating water levels are also an obstacle to water transportation, necessitating the installation of costly dumping and reloading facilities. Therefore, the road system should be fully developed along the reservoir at the time of dam construction.

In the areas where reservoirs flood the valley bottoms, the use of grazing resources may be curtailed or drastically changed. Livestock allotments which occupy both slopes of a drainage to be flooded are divided by the reservoir, and management and administration costs are sharply increased. At lower elevations lambing grounds may also be inundated. If private commensurate lands are flooded, the grazing permittee may be forced to acquire other lands or relinquish his grazing privileges. Also, the lack of a well-developed road system is likely to increase the cost of fire control. In rough topography where roads are not economically feasible, it may be possible by the use of boats to move small numbers of men and their supplies along the reservoir. (Pleasant Valley and Mountain Sheep on the Snake River are examples; the reconstruction of a trail in this area would average $100,000 per mile.)

Experience has shown that large reservoir construction is inevitably followed by immediate, heavy public demand for recreational facilities along the shoreline. Flooding of optimum recreation sites is likely to be a restrictive influence in recreation planning. In many of the plans prepared to date, provisions for comprehensive survey and broad recre tion planning have been entirely inadequate. The survey and plans should become a part of the integrated project development plan.

In many locations the lower elevations and valley bottoms are a part of the winter range for big game animals. The winter range may be divided, as in livestock allotments; this will interfere with or curtail

the migration of big game. In many instances the fish production is changed. Fluctuations in reservoir levels are not conducive to the successful propagation of many species of game fish, and it may be necessary in many cases to modify management plans.

Flooding of ranger station developments is often a problem. Less advantageous locations may be required; administrative unit boundaries and communication and transportation facilities may have to be readjusted with reference to major work areas.

The flooding of large areas may have the most far-reaching influence on the economic and social life of local, affected communities. The extent of these influences is governed largely by:

1. Location of the dams.

2. Height of the dams.

3. The seasonal or operational fluctuations of the water levels.

I would like to comment on these in more detail.

1. <u>Location of the dams in relation to the communities within the area</u>. Transportation systems should serve communities economically and with due regard for the future delivery of forest products. It would be possible, of course, for transportation costs to increase to such a high level that some productive areas may be excluded from planned units. Increased costs for transportation facilities do not stop with the construction cost alone; to this must be added the increased cost of capital outlay, maintenance and increased cost of moving logs. Mainline railroad routes are often dislocated when large reservoirs are built. This may prove to be both difficult and expensive. Curvature, alignment and gradient are likely to permanently increase transportation costs.

2. <u>Height of dam</u>. Efforts should be made to utilize the total maximum output of a river. From the engineering and economic standpoint, it must be recognized that this objective may be modified to minimize the impact on land uses along the stream course.

3. <u>Seasonal or operational fluctuations of the water level</u>. It has been determined that there is a maximum height at which logs can be economically lowered and raised from the lake level. This maximum seems to be between sixty and eighty feet. Any reservoir which would have an annual or operational fluctuation greater than eighty feet would result in a prohibitive increase in lake surface transportation costs. Low value forest products resulting from thinnings and timber stand improvement cannot be economically handled by methods requiring increased costs of transportation.

Water levels are an important influence in the production of fish and the use of the area for recreational purposes. During the summer months, it is desirable to retain water levels at maximum for aesthetic and recreational purposes. In addition, wide fluctuations in water level may have a serious effect on the extent and character of the fish population.

I have attempted to cover the important points for long-range administrative consideration in large dam construction. More dams are proposed for construction and many of these dams and their reservoirs will be located within or near the boundaries of national forests and will affect the administration and use of national forest lands. To enable the Forest Service, as the land managing agency, to adequately redeem its responsibility where construction of dams and reservoirs involves National Forest lands, it is necessary that they actively participate in all stages of planning. In planning, full recognition should be given to all basic resources, their administration and use.

WATERSHED MANAGEMENT IN ADMINISTRATION

Identification of points of conflict and areas for coordination between Watershed Management and its impact on special programs

Municipal watershed . . . . K. A. Klehm

Myrtle Creek on Kaniksu is municipal water supply for Bonners Ferry. Low dam constructed approximately 30 years ago with no settling basin. Water always ran clear and clean.

Area burned same year dam was built, some mud slides occurred, but no appreciable change in water supply.

Heavy windfall in ponderosa pine occurred in 1951 on Myrtle Creek. Roads were hastily constructed without sufficient drainage, ditching, etc. Logging started in November 1952. Spruce beetle hit area later and logging started again; 20,000 M on private land and 10,000 on Forest Service. Logger did good job, damage was caused by roads. Water now contains glacial silt and other dirt causing discoloration to Bonners Ferry water supply. Mayor blames Forest Service. Forest Service previously enjoyed wonderful reputation in community. Forest has planted grass, scattered brush to stop erosion. Mayor thinks Forest Service should pay for siltation plant at cost of $210,000.

Trouble could have been prevented had we had a previously prepared plan of logging. Plan should be prepared 15 years in advance on any area upon which logging is contemplated.

Plan could consider topography, soils, timber sale policy, main haul roads, etc.

Main haul roads should be located far as possible from streams, 400 feet if possible.

Roads should be designed and constructed in accordance with best engineering standards.

Culverts should be properly spaced and located. Culverts should be in bottom of drainage.

Water barriers should be constructed.

Slopes should be seeded.

Protective timber strips should be left along streams.

Sanitary facilities should be provided.

All probable effects of timber harvest on municipal watershed should be considered.

The Kaniksu Forest has prepared a plan and instruction for the development of the Myrtle on watershed. Copies may be obtained by writing to the Forest Supervisor, Kaniksu National Forest.

SPECIAL PROGRAMS

Public Law 566 . , ... H. L. Lobenstein

Introduction

Members of this conference are probably generally familiar with the Watershed Protection and Flood Prevention Act, more commonly known as Public Law 566. It, therefore, seems desirable and possibly more profitable to discuss some of the ways in which this Act affects the Forest Service with brief mention of significant problems which have arisen in our efforts to participate in this new legislative approach to watershed problems with which we have struggled for many years.

Legislative and Administrative Guidelines

The principal legislative and administrative actions which govern the application of this Act and the working arrangements between agencies include the following:

A. Applicable to all agencies.

1. Public Law 566 - The Watershed Protection and Flood Prevention Act. 83rd Congress, 2nd Session.

2. Executive Order #10584 issued December 18, 1954.

3. Title 9 - U.S.D.A. Administrative Regulations as Amended November 1954 (Chapters 3 and 4).

4. Policy Statement - Secretary of Agriculture, dated March 14, 1955.

5. SCS Interim Handbook issued in April 1955 (Revised edition now being compiled).

B. Applicable to Soil Conservation Service and Forest Service.

Additional policy and procedural guidelines relating specifically to working arrangements between the Soil Conservation Service and the Forest Service include:

1. Joint letter to field personnel by D. A. Williams, Administrator, SCS, and Richard E. McArdle, Chief, Forest Service, dated September 2 and 7, 1954.

2. Joint letter to field personnel by Carl Brown, Director, Planning Division, SCS, and Warren Murphy, Chief, Division of Flood Prevention and River Basin Planning, Forest Service, dated November 8, 1954.

Numerous additional memoranda by both the Forest Service and the Soil Conservation Service addressed to their respective field personnel explain and amplify the broad guides which I have listed. Items A1, 2, 3, 5, and B1. are included in the SCS handbook and it is expected that the Forest Service will receive at least enough copies to distribute to forest supervisors. In addition, it is planned that a watershed management section of the Forest Service Manual will be drafted within the next few months. Undoubtedly most of the guidelines mentioned will be abstracted or referred to therein.

<u>Authority for the Forest Service to do Watershed Work</u>

The several legislative authorities under which the Forest Service operates in administering national forest and LU lands and in cooperating with the states in providing assistance to the owners and operators of privately owned forest lands appear to provide ample authorization for watershed work.

Practically all of the forestry measures which might be included as a part of P. L. 566 projects could also be legally done under these earlier basic authorities.

The principal reason why we have not accomplished more needed watershed improvement work under our basic authorities is that we have not yet been able to obtain sufficient funds under those authorities.

However, this situation does not preclude the possibility that our so-called "regular programs" may be utilized to a greater extent in the future to accomplish some of the watershed restoration and protection work which remains undone. The addition of a small sum to our F. Y. 1956 appropriation for that specific purpose is an encouraging sign.

Consideration should be given to the possibility that attempts to achieve flood prevention goals on national forest lands solely through our regular programs may not be fully compatible with the growing concept that watershed protection and flood prevention programs should be conducted as complete programs on all of the lands within an individual, integral hydrologic unit.

It is apparent that P. L. 566 in its present form can be utilized to solve only a comparatively small part of the critical watershed problems on lands administered by the Forest Service. This is perhaps more true of Regions 1 and 6 than for other parts of the country. Facing such a situation, all possible avenues of approach to the solution of watershed problems should be understood and explored. While I believe that P. L. 566 affords an opportunity which should not be overlooked or neglected, it ought not be considered as a panacea for all of our watershed problems.

Before leaving this part of my subject, mention should also be made of several of the other ways in which the Forest Service may do watershed protection or flood prevention work.

The Flood Control Act of 1936 with subsequent amendments provided

authority for the installation and maintenance of flood prevention measures on national forest lands. While P. L. 566 repealed those parts of the 1936 Act relating to participation by the Department of Agriculture on additional watersheds, authority for continued participation on the eleven approved flood control projects was not withdrawn. Forest Service interest in these projects is substantial as is indicated by the fact that the expected Forest Service appropriation for F. Y. 1957 for use on these projects is about $1,230,000. However, since none of the projects are in Region 1 and the door is closed for additional projects under the Act, further comments are unnecessary.

Another section (216) of the Act of 1936 as amended in 1950 which was not repealed authorizes the Secretary of Agriculture to use up to $300,000 annually for emergency measures following fire, flood or similar catastrophe. These funds are available for use anywhere in the country but can be used only when measures for the immediate protection of lives and valuable property cannot be adequately accomplished through regular programs of the Department plus local effort.

There may be instances in Region 1 where requests should be made for financial assistance from this emergency fund. At least the rules under which it can be made available should be understood. For this information, I refer you to the Chief's FP, PROGRAMS, Emergencies, Policy letter of September 16, 1955, to Regional Foresters.

From this point on I will confine my remarks to P. L. 566 as it applies to the work of the Forest Service.

Eligibility of Federal Land to Participate in P. L. 566

Although P. L. 566 itself may appear somewhat vague on this point, a study of the congressional hearings which preceded its passage indicates the intent of Congress that federal lands within approved watersheds would participate in the planned program. Also that the agencies responsible for such federal lands would be expected to participate in planning and execution phases with respect to the lands for which they are responsible.

The President's Executive Order (#10584 dated 12/18/54), the policy statement of the Secretary of Agriculture dated March 14, 1955, affirm and more explicitly state that the P. L. 566 program will in include federal lands. Other policy and procedural guidelines including the SCS handbook establish working arrangements to facilitate such participation.

It must be kept in mind that on federal lands present policy limits the use of P. L. 566 funds to eligible measures which cannot be accomplished with "regular" or "going" programs within a reasonable length of time. Briefly, on federal lands P. L. 566 can be used to supplement "going" programs but not as a substitute for them.

Aspects of P. L. 566 which Limit its Application to National Forest Lands

It has been said that this Act was originally designed to meet watershed problems of the mid-West and South. Whether or not this is true, the fact remains that the Act in its present form does not very well fit physical conditions in much of the Western part of the country.

Briefly, the provisions of the Act which now appear to restrict its application in the West include the following:

1. Limitation of size of projects to 250,000 acres is a handicap in the West where many of the hydrologic units are of much larger size. Distance and area separating flood and sediment source areas from damage areas frequently exceed this limit and very often the alternative of combined planning of sub-watersheds is not feasible.

2. The provision that local organization must initiate action by requesting assistance is certainly sound and desirable. However, it often places us at a disadvantage where large areas of federal land are involved. Again distances between the mountain slopes and well populated communities where local organizations exist is the chief problem. Prerequisites for the development of P. L. 566 projects include:

    a. People and property in the watershed are frequently damaged by flood water or sediment and the degree of damage is important.

    b. A qualified "local organization" exists or can be readily formed.

    c. Residents of the watershed are aware of the source and cause of floods and there is an organized and strong desire for a corrective program.

    These conditions are not now present on many watersheds in which the Forest Service has a direct interest. On some, the chances for obtaining a project may be so remote that our efforts should be directed elsewhere. In other instances our informational program may need to be stepped up before concrete action is taken by local organizations.

3. Very often depleted national forest watershed land produces floods which damage distant downstream communities. At the damage point, people are concerned and want something done but relating damages to cause and source is difficult. "Local beneficiaries" may not have jurisdiction in the place where the work needs to be done. People in the damage area are not apt to share in the cost of remedial work needed upstream unless they believe that they will receive significant and identifiable benefits. A pending amendment to the Act would permit the federal government to bear most of the cost of structural measures for flood prevention. If passed by the Congress, this change might increase the chances for projects in situations such as I have just described.

4. Many proposed projects in all parts of the country now appear to be subject to deferral or withdrawal because local people are either

unable or unwilling to accept the degree of cost sharing now required. Again there is a movement of some magnitude to change the rules so that the local share of project costs would be reduced. If such changes are made, and I make no predictions, it is very probable many potential and proposed projects which now appear doubtful would come into the picture.

5. In some places field personnel have not been favorably inclined toward proposed projects which included large amounts of federal land. Lack of understanding of the eligibility of federal lands to participate has probably been the chief reason for this situation. Indications are that we very likely will experience less trouble of this sort in the future.

Problems of Administration and Organization

It is evident that many of the problems encountered in our attempts to participate in getting the P. L. 566 program underway stem from the fact that primary, overall administrative responsibility is assigned to the SCS. While the Forest Service is in effect a "junior partner," our actions and procedures are subject to review and concurrence by the SCS. While this may appear to be a cumbersome and often unsatisfactory procedure, it is Departmental policy and we are obliged to exercise every reasonable effort to make it work.

All of the P. L. 566 funds are received by the SCS and those which the Forest Service receive are reallocated to us following negotiation with the SCS.

Areas of Conflict

Mention has already been made of several of the more general points of conflict or misunderstanding between the SCS and the Forest Service regarding conduct of this program and agency participation therein. I believe that the revised SCS handbook expected to be distributed to field offices of both agencies within the next two months will aid materially through more clearly stated and specific instructions regarding inter-agency relationships. A few items merit specific mention. These are:

1. There should be no further question regarding eligibility of federal land to participate. Current policy statements of the SCS which have been distributed to field personnel of both agencies are clearly stated and emphatic on this point.

2. At upper levels of both agencies there is agreement that acceleration of justifiable land treatment and flood prevention measures proposed on federal lands do not have to be financed from funds now obtained through the "regular programs" of such agencies. Administrative policy of the Department and the position of the Forest Service requires

That these "regular programs" will be used to the maximum extent compatible with other obligations to accomplish the desired objective on approved P. L. 566 projects. As stated before, it is the policy that P. L. 566 funds will be used to augment other programs and not as a substitute or replacement.

3. Measures which we propose to install on national forest lands have been questioned by SCS personnel as not being eligible. Frankly, we have not been in a thoroughly defensible position in a few cases. In the future more care will need to be taken to insure that measures which we propose as a part of P. L. 566 projects will meet the criteria for participation by providing significant effects in reducing flood and sediment damages.

4. The most widespread and troublesome problem regarding inter-agency working relationships in connection with this program has been the matter of technical assistance to the owners and operators of non-federal forested lands. The Forest Service is therefore much concerned and is striving toward early solution and agreement.

   The problem is currently a matter of considerable concern in the top levels of both agencies and negotiations are now underway between the Forest Service and the SCS for the purpose of developing policies and procedures to which both agencies can agree.

In the meantime we should make every effort to work in a friendly manner with state and local representatives of the SCS on a case by case basis. In doing this, our objective should be that of providing adequate technical assistance to the private land owner. Plans so developed should be in accord with existing legislation and presently assigned administrative responsibilities and at the same time provide adequate technical assistance to private land owners.

Other factors include the following:

1. Some people do not yet realize that the Forest Service has an interest in meetings and negotiations with local people where forestry problems are involved.

2. Lack of appreciation by many of conditions and problems on wild lands. Many do not have a general knowledge of runoff and erosion characteristics of mountainous lands and the hydrologic behavior of mountain streams.

3. The philosophy that land treatment measures should come first is not universally accepted and land treatment needs are sometimes sacrificed in favor of structural work.

4. Professional differences between federal agencies on technical range and forestry problems and their solution.

5. Many personnel have little knowledge of procedures, policies, and background of the other agency.

6. Insufficient participation by some Forest Service personnel in conservation matters on lands other than those administered by the Forest Service.

7. Failure by some Forest Service people to recognize that structural work has a real place in flood prevention programs. Land treatment alone will not do the whole job on some watersheds.

8. Lack of appreciation by many Forest Service people of the problem facing the SCS in getting programs installed on private land.

9. Failure by some Forest Service people to take aggressive action in encouraging and fostering off-forest programs which would complement our programs and make our task easier.

This adds up to a big job for both agencies if the P. L. 566 program is made to work in the way the public expects it will. Much progress has been made by both Forest Service and SCS personnel at all levels in developing a better understanding of the situation and in developing workable solution for many problems, but much remains to be accomplished. Friendly acquaintance between personnel is a good starting point. Understanding of the other fellow's job and respect for the responsibilities with which he is charged are equally important. These things cannot be accomplished overnight but we should work constantly toward that goal.

Outlook for Future Work Under P. L. 566

In the overall sense the P. L. 566 program is being attacked and criticized because of the slow rate of progress and the amount of effort and money being expended in preliminary planning. We must aid the SCS in all feasible ways to remove the causes of these complaints.

Because of limiting factors already mentioned it is probable that relatively few watersheds in Region 1 will become approved P. L. 566 projects. However, this situation should not be allowed to diminish our interest or efforts on those watersheds which appear to meet present requirements for assistance under this Act.

The Act and related policy may be amended in ways which will increase the potential for projects in this area. Changes already proposed could have that effect, but in the main they will require changes in the present Act by Congress. In the meantime, we need to work more aggressively and intelligently with the authorization and guidelines now available.